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ART. I.—*On Certain Harmonies of the Solar System;* by Professor DANIEL KIRKWOOD, Indiana State University.

I.—THE ROTATIONS OF THE PLANETS.

IN 1849, a very simple formula connecting the rotations of the planets, and harmonizing in a remarkable manner with the elements of the solar system so far as known, was communicated to the American Association for the Advancement of Science. This formula represented the rotation-period of Uranus, which had never been observed, as greater than that of any other planet. Hence a determination of the true rotary velocity would have been regarded as a test of the new harmony. The number of powerful instruments had then been recently increased, and Uranus was approaching a more favorable position for accurate examination. Little doubt was therefore entertained that the claims of this planetary law would soon be decided by telescopic discoveries. Inasmuch, however, as no definite results have yet been obtained, a brief review of the facts may not be destitute of interest.

If the solar system has resulted, as was supposed by Laplace, from the gradual contraction of a rotating nebulous spheroid, what was probably the physical constitution of the abandoned equatorial rings in the first stages of their separate existence? The celebrated author of the nebular hypothesis supposed each of the rings in which the several planets originated to have revolved, during an indefinite period before its dissolution, as one continuous mass. "These zones," he remarks, "ought, according to all probability, to form by their condensation and by the

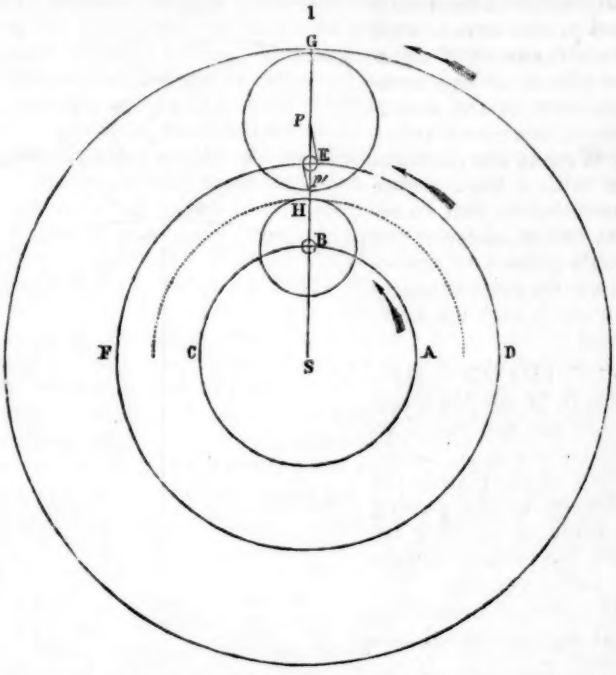
mutual attraction of their particles, several concentric rings of vapor circulating about the sun. The mutual friction of the molecules of each ring ought to accelerate some and retard others, until they all had acquired the same angular motion. Consequently, the real velocities of the molecules which are *farther* from the sun ought to be greatest."[1] This view has also been generally adopted by later advocates of the nebular theory. Instead, however, of each planet's having existed as a single, continuous ring, may not each have consisted of many? Such, according to the investigations of Professors Bond, Peirce, and Maxwell, is the present constitution of Saturn's rings.[2] The conclusion reached by the last named writer is "that the rings must consist of disconnected particles: these may be either solid or liquid, but they must be independent. The entire system of rings must, therefore, consist, either of a series of many concentric rings each moving with its own velocity and having its own system of waves, or else of a confused multitude of revolving particles not arranged in rings and continually coming into collision with each other." Now the physical condition of the *primary* rings was probably somewhat analogous. After the process of separation commenced, we may suppose a continued succession of rings to have been thrown off in close proximity to each other, each revolving round the central mass in accordance with Kepler's third law.[3] The result, then, of a gradual condensation would be a central body surrounded by an indefinite number of concentric rings, or, rather, of disconnected planetary molecules, all moving in the same direction. The mutual attraction of some of these particles, when coming into close proximity to each other, would cause them to unite, and in this way we may suppose the planetary nuclei to have been first established. In the subjoined diagram, let S be the center of the solar mass; ABC and DEF the orbits of two adjacent planetary nuclei, B and E; and H the point of equal attraction between them. Let also p, p' be particles revolving round the center, S, in approximate accordance with the third law of Kepler. Their motion is disturbed by the attraction of E, and, in consequence, they finally coalesce with it. But the orbital velocity of p is *less* than that of E, while, on the other hand, that of p' is *greater*. It is obvious, therefore, that they would not approach the nucleus in lines normal to its surface. The point of contact of the *outer* particle would be *behind* the center, that of the *inner* one in *advance* of it. These particles, then, would act as oblique

[1] Syst. of the World, Harte's Translation, vol. ii, p. 359.

[2] Gould's Astr. Jour., vol. ii, No. 1, May 2d, 1851; vol. ii, No. 3, June 16th, 1851; and vol. iv, No. 14, Sept. 5th, 1855. Also, Maxwell's Essay on the Stability of the Motions of Saturn's Rings, p. 67.

[3] This law, we are aware, would but imperfectly represent the motions of the individual particles of the rings.

forces; their tendency being to produce a rotation in a direction *contrary* to that of the orbital motion. When the planetary mass, however, had gained considerable magnitude, the solar



attraction would produce a tidal elevation on the hemisphere toward the sun. The gravitating force of this protuberant matter would maintain the greatest axis, during an indefinite period, in the direction of the central body; thus causing an equality between the angular velocities of rotation and orbital revolution, such as is now found to obtain in the case of the secondary planets.

Let us now consider the consequences of further condensation.

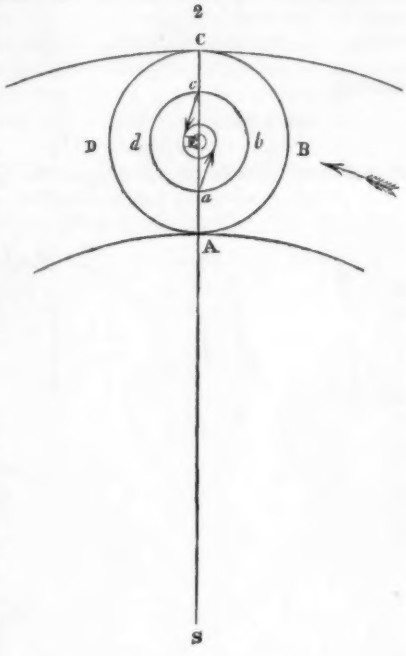
Let S be the center of the solar mass;

AC = D = the diameter of a planet's sphere of attraction;

and *ac* = the diameter of the vaporiform planet at the close of the epoch of equality between the angular velocities of the rotary and progressive motions.

It is obvious that the orbital velocity of a particle at *c* must be *greater* than that of the center of the mass, while that of a particle at *a* must be *less*. Any further contraction of the spheroid must tend therefore, to accelerate the rotation *in the direction*

of the orbital motion. It must also be manifest that the rotation-period at the epoch of solidification will depend upon the ratio of *ac* to SE. Now, it may be impossible to determine in any particular case what was the diameter of a gaseous planet at the commencement of the acceleration of the rotary velocity. We may assume, however, with a high degree of probability, that its ratio to the diameter of the planet's sphere of attraction was the same or nearly the same in each instance; or that



$$\Delta : \Delta' :: D : D'; \qquad (1)$$

where D, D′ are the diameters of the spheres of attraction, and Δ, Δ′, the diameters of the planets immediately before passing the limit of equality between the periods of rotation and revolution.

The law of rotation as originally announced is as follows:—

"Let P be the point of equal attraction between any planet and the one next interior, the two being in conjuction: P′ that between the same and the one next exterior.

Let also D= the sum of the distances of the points P, P′ from the orbit of the planet; which I shall call the diameter of the sphere of the planet's attraction;

D′= the diameter of any other planet's sphere of attraction found in like manner;

n= the number of sidereal rotations performed by the former during one sidereal revolution round the sun;

n'= the number performed by the other; then it will be found that

$$n^2 : n'^2 :: D^3 : D'^3." * \qquad (2)$$

Let, now, T, T′= the periodic times of two planets;

t, t'= their periods of rotation;

and d, d'= their mean distances from the sun;

* Proc. Am. Assoc. for the Adv. of Sci., 2d Meeting, held at Cambridge, 1849, p. 207.

then (2) becomes

$$\left(\frac{T}{t}\right)^2 : \left(\frac{T'}{t'}\right)^2 :: D^3 : D'^3 ; \text{ or, by Kepler's third law,}$$

$$\frac{d^3}{t^2} : \frac{d'^3}{t'^2} :: D^3 : D'^2 ;$$

whence

$$t^2 : t'^2 :: \left(\frac{d}{D}\right)^3 : \left(\frac{d'}{D'}\right)^3 \qquad (3)$$

or, assuming the truth of proportion (1),

$$t^2 : t'^2 :: \left(\frac{d}{\Delta}\right)^3 : \left(\frac{d'}{\Delta'}\right)^3 \qquad (4)$$

It is seen on the slightest examination that in the solar nebula, as well as in each of the gaseous planets, the ratio of the revolving or equatorial radius to the radius of gyration varied throughout the entire process of condensation: in other words, that the rate of variation of density from surface to center was constantly changing. Were the solar mass expanded so as to fill the earth's orbit, the rate of variation of density remaining the same, the period of rotation would not be 365 days, but 5457. The diameter corresponding to one revolution in a sidereal year would be only 12,720,000 miles. If we compute the values of the principal radius of gyration when the spheroid extended to the present planetary orbits respectively, we find that the solar mass had reached a high degree of central condensation before the epoch of Neptune's separation. We find, moreover, that the condensation advanced much more rapidly about the center than near the surface of the contracting mass. Probably it became so great as to produce chemical action, thus forming a nucleus in a state of igneous fluidity by the precipitation of the denser portion of the nebula, long before the exterior parts had passed from their original gaseous condition.

It is not necessary to suppose, as has been generally done, that if the nebular hypothesis be true the outer planets of the system must have an immensely greater antiquity than the interior. The formative processes in the different cases may have been contemporaneous.[4] In this view of the case, it seems probable that the remoter planets are less advanced in their physical history than some nearer the sun. The formation of a single planet from matter diffused around the circumference of a larger circle, would undoubtedly require more time than the aggregation of a ring of smaller dimensions. Possibly there may be

[4] Since writing the above, we have been favored with the reading of some highly interesting researches on the nebular hypothesis, by DAVID TROWBRIDGE, Esq., of Perry City, N. Y. These mathematical investigations sustain the probability of the synchronous formation of different members of the solar system. We are gratified to know that Mr. T. is preparing a treatise on this subject for the press, and trust it may soon be given to the public.

rings exterior to Neptune still in the nebular state, or at least not yet collected about a single nucleus.

It has been shown that, according to the nebular theory, a planet's time of rotation ought to be *some* function of the ratio of the radius of its orbit to the diameter of its sphere of attraction. Those ratios are very nearly equal in the case of Jupiter and Saturn; the periods of rotation are also nearly identical: the ratio, however, is somewhat greater in the case of Saturn; so also is the time of rotation. The ratios again are not very different in the cases of Mercury, Venus, the Earth and Mars; and again *in each instance* a greater ratio corresponds to a slower rotation. The *form* of the function as expressed by the equation,

$$\frac{T}{tD^{\frac{3}{2}}} = \text{a constant},$$

was found by a tentative process.

This analogy indicates, as we have stated, a longer period of rotation for Uranus than had been *conjectured* by some astronomers. It assigns, however, a physical *cause* for this slow revolution; while the short period of nine hours and a half, assumed by some writers, has no such basis. The best observers have failed to detect any such polar compression of the planet as would indicate a rapid revolution. "Professor Mädler," says Mr. Hind, "thinks he has detected a very considerable ellipticity in the form of the planet, and makes the ratio of the equatorial to the polar diameter as ten to nine, the axis being inclined at an angle of 15° 26′ to the circle of declination (1843, September 28). Other astronomers, with more powerful telescopes, have not succeeded in gaining any certain evidence of an appreciable difference in the diameters. Mr. O. Struve has informed me orally that the grand refractor at Pulkova affords no indications of ellipticity."[*] The Rev. Robert Main, of the Royal Observatory, Greenwich, states that at his request "Professor Challis obligingly measured the planet, some years ago, with a double image micrometer attached to the telescope of the great Northumberland equatorial, for the purpose chiefly of discovering whether it had any sensible ellipticity, which the author suspected from some measures of his own made with a far inferior telescope. The result was that the ellipticity is too small to be measurable."[*] These measures were made at nearly the same time with those of Mädler. The disk of Neptune, also, even when viewed through the most powerful telescopes, appears perfectly circular. Now the degree of ellipticity correspoding to a short period of rotation, nearly equal to that of Jupiter or Saturn, would undoubtedly be so great, especially in the case of Uranus, as to be easily recognized. The preponderance of evi-

[*] Hind's Solar System, p. 121. [*] Main's Rudimentary Astronomy, p. 130.

dence, therefore, apart from the reason assigned by my analogy, is unquestionably in favor of a long period of rotation.

It is easily shown that the equality between the angular velocities of rotation and orbital revolution, which obtains in the secondary systems, is not incompatible with the law of rotation. When the volumes of the primary planets had the same ratio to their spheres of attraction as those of the satellites now have to theirs, the former were still in a state of vapor, their masses extending beyond the present orbits of the secondaries, and not having reached, in all probability, the limits of equality between the two angular velocities in their respective cases. Had the satellites, at the corresponding epoch in *their* history, been equally rare, so that any increase in rotary velocity would not have been prevented or arrested by solidification, the same law would doubtless have obtained in the secondary systems.

I have believed, however, almost from the time of its first announcement, that the statement of my analogy requires some modification. If it be the expression of a physical law, it must depend on the relation between the primitive momentum of rotation and that of orbital revolution. Now the time of rotation of any planet having satellites is evidently greater than it would have been had the entire mass condensed in a single body. In order, therefore, to find the proper constant of rotation for the earth, we must determine the time in which its axial revolution would be performed were the matter of the moon diffused over its surface; the momentum of the satellite's orbital motion being converted into momentum of rotation.

The earth's momentum of rotation cannot be known with accuracy, because the rate of variation of density from surface to center has not been determined. It is probable, however, that the mean density is nearly attained not far from the surface, and that no very important error would result from considering the radius of gyration to be that of a homogeneous sphere. Adopting this hypothesis, we obtain, by an easy calculation in mechanics, about 22h. 48m. as the rotation period of the united mass. The corresponding number of days in a year would be 384·4.

The sum of the masses of Jupiter's satellites is only about $\frac{1}{8\,0\,0\,0}$th, the mass of Jupiter being 1. The sum of the masses of the Saturnian satellites is still less as compared with their primary. In a calculation of this nature, therefore, the acceleration of the rotary velocities of these planets from the precipitation of their secondaries may be wholly neglected. The mass of Saturn's ring, however, according to Bessel, is $\frac{1}{1\,1\,8}$th, that of the primary being 1. A calculation similar to that which we have made for the earth and moon shows that the precipitation of even this mass upon the planet would shorten the period of rotation

only about 17 minutes. But with Bond's estimate of the thickness of the ring, this value of the mass would indicate a density more than three times that of Saturn—a greater density than has been found for any planet, primary or secondary, exterior to Mars. This result seems too improbable to be admitted without confirmation. We have thought it best, therefore, in this state of the case, to adopt, without alteration, the received value of Saturn's period of axial revolution, viz: 10h. 29m. 17s.

If we use the masses of Jupiter, Saturn and Uranus, adopted in the *American Nautical Almanac*, we find the diameter of Saturn's sphere of attraction = 8·5478. Hence the constant of rotation

$$C = \frac{n}{D^{\frac{3}{2}}} = 985{\cdot}161\,;\ \log C = 2{\cdot}993507.$$

The diameters of the spheres of attraction for the other planets are then found from the formula

$$\log D' = \tfrac{2}{3}\,(\log n' - \log C).$$

The results, tabulated, are as follows:—

Diameter of the sphere of attraction of				Mercury,	0·1992
"	"	"	"	Venus,	0·3801
"	"	"	"	Earth,	0·5340
"	"	"	"	Mars,	0 7731
"	"	"	"	Jupiter,	4·8342
"	"	"	"	Saturn,	8·5478

Let us now find the corresponding masses of Mercury and Mars, together with the mass and distance of the asteroid planet. We will employ the mass of the earth given in the *American Ephemeris*. Leverrier's value of the mass of Venus there adopted is probably somewhat too large, as seems to have been more recently admitted by Leverrier himself. We will, therefore, take Encke's value, $\frac{1}{4\,0\,1\,2\,3\,7}$. The calculation is obvious and need not be repeated. We find

The mass of Mercury = $\frac{1}{3\,5\,0\,7\,7\,0\,0}$.
" " Mars = $\frac{1}{3\,0\,9\,7\,1\,0\,0}$.
" " Asteroid Planet = $\frac{1}{1\,2\,3\,1\,1\,1\,5\,7}$.
Distance of the Asteroid Planet = 3·1116.

Remarks.

1. This value of Mercury's mass is considerably greater than that found by Encke, but is very nearly identical with Leverrier's second value.

2. Our mass of Mars is somewhat less than Burckhardt's. Mr. Airy's researches on the theory of the sun have led him to the conclusion that a considerable diminution of that value is actually demanded.[7]

[7] Grant's Hist. of Phys. Astr., p. 129.

3. The resulting mass of the asteroid planet is less than one-third that of the earth; about the limit assigned by Leverrier for the mass of the zone of asteroids.

Researches of Professor Hinrichs.—The learned and interesting paper on the density, rotation, and relative age of the planets, in the American Journal of Science and Arts, for January, 1864, by Professor Hinrichs, would seem to enhance the difficulty of developing any order either in the *present* arrangement of the members of the solar system, or their revolutions on their axes. The conclusions of Professor H., however, depend upon the existence of a resisting medium, the only indication of which is found in the shortening of the period of Encke's comet. Encke himself regards this resistance as insensible exterior to the orbit of Venus. Now if the zodiacal light consists of solar rings, the sensible resistance of the comet is limited to the time of its passage through them. May we not thus find a sufficient cause for the diminution of the period?—and ought not all speculations in regard to the effect of the medium on the motions of the remoter members of the planetary system, to be received with caution, until we have some further evidence of its existence?

With respect to the want of harmony in the present arrangement of the planetary orbits, Prof. Hinrichs remarks as follows:

"The present configuration of the planetary system is without that harmony and order everywhere else observed where matter is aggregating (e. g. in crystals, etc.); we must therefore suppose that the original harmonious configuration has been altered by the action of some general cause, displacing the celestial strata (orbs) according to the individual mass, size, and position of each body; the same we know to have occurred in the case of the earth's figure, being at first ellipsoidal, but now to some extent irregular—or the terrestrial strata of rocks, which were at first continuous, but are now greatly dislocated. This cause has been, and is, *the resistance of the ether* filling the heavenly space in which the celestial globes are moving; for the mathematical investigation of the effects of such a resistance agrees perfectly with the phenomena observed."[8]

Without entering upon any special discussion of this interesting subject, we respectfully submit the following considerations:

1. The hypothesis adopted by Encke in regard to the medium which causes the acceleration of the mean motion of his comet, is that the density varies inversely as the square of the distance from the sun, and that the resistance is proportional to the density of the medium and the square of the velocity of the moving body.

[8] Am. Jour. of Sci. and Arts, Jan., 1864, p. 55.

2. Granting the existence of an ethereal medium, it would seem unphilosophical to ascribe to it one of the properties of a material fluid—the power of resisting the motion of all bodies moving through it—and to deny it such properties in other respects. Its condensation, therefore, about the sun and other large bodies must be a necessary consequence.

3. This condensation existed in the primitive solar spheroid, before the formation of the planets: the rotation of the spheroid would be communicated to the ether co-existing with it: *hence, during the entire history of the planetary system, the ether has revolved around the sun in the same direction with the planets.*

4. This condensed ether must participate in the progressive motion of the solar system.

5. Even if we reject the doctrine of the development of the planetary system from a rotating nebula, we must still regard the density of the ether as increasing to the center of the system. The sun's rotation, therefore, would communicate motion to the first and denser portions; this motion would be transmitted outward through successive strata, with a constantly diminishing angular velocity. The motion of the planets themselves through the medium in nearly circular orbits would concur in imparting to it a revolution in the same direction.

6. Whether, therefore, we receive or reject the nebular hypothesis, the resistance of the ethereal medium to bodies moving in orbits of small eccentricity and in the direction of the sun's rotation, becomes an infinitesimal quantity.

7. The doctrine of a resisting medium is not generally accepted by astronomers as an established fact. "It is manifest," says an eminent writer, "that more extensive indications of such a medium must be discovered before the problem of its existence can be considered as having received a definitive solution. It has not yet affected to a sensible extent any of the other celestial bodies, and, until such is found to take place, the question relative to it must remain in abeyance."[*]

II.—The Planetary Distances.

As long ago as the commencement of the seventeenth century, the celebrated Kepler observed that the respective distances of the planets from the sun formed nearly a regular progression. The series, however, by which those distances were expressed, required the interpolation of a term between Mars and Jupiter—a fact which led the illustrious German to predict the detection of a planet in that interval. This conjecture attracted but little attention till after the discovery of Uranus, whose distance was found to harmonize in a remarkable manner with Kepler's order of progression. Such a coincidence was of course regarded

[*] Grant's Hist. of Phys. Astr., p. 135.

with considerable interest. Toward the close of the last century, Professor Bode, who had given the subject much attention, published the law of distances which bears his name, but which, as he acknowledged, is due to Professor Titius. According to this formula, the distances of the planets from Mercury's orbit form a geometrical series of which the ratio is two. In other words, if we reckon the distances of Venus, the earth, &c., *from the orbit of Mercury*, instead of from the sun, we find that—interpolating a term between Mars and Jupiter—the distance of any member of the system is very nearly half that of the next exterior. The series is usually expressed as follows:—

$$\begin{aligned} 4 &= 4 \\ 4+3\times 2^0 &= 7 \\ 4+3\times 2^1 &= 10 \\ 4+3\times 2^2 &= 16 \\ 4+3\times 2^3 &= 28 \\ \text{\&c.} &\quad \text{\&c.} \end{aligned}$$

The numbers 4, 7, 10, &c., represent approximately the relative distances of Mercury, Venus, the earth, &c., from the sun. The ninth term, however, which corresponds to Neptune, is 388, instead of 300. It was, moreover, remarked by Gauss that "the member which precedes $4+3$ should not be 4; i. e. $4+0$, but $4+1\frac{1}{2}$. Therefore, between 4 and $4+3$, there should be an infinite number; or, as Wurm expresses it, for $n=1$, there is obtained from $4+2^{n-2}\times 3$, not 4, but $5\frac{1}{2}$."

Professor Challis has applied a modification of Bode's empirical formula to the secondary systems of Jupiter, Saturn and Uranus;[10] his coincidences, however, are far from exact. The formula itself, as well as the modifications by Wurm and Challis, may be expressed—commencing with the greatest distance and proceeding toward the center—by the series,

$$a+br^n,\ a+br^{n-1},\ a+br^{n-2},\ \&c.$$

In the scheme of Bode and Titius, $a=4$, $b=3$, and $r=2$; in that of Wurm, $a=387$, $b=293$, and $r=2$. Both fail to represent, even approximately, the relative distances of Mercury and Neptune.

I have never doubted that the planetary distances were arranged in *some* discoverable order. These failures, however, in the series of Titius have seemed a sufficient cause for its rejection, or, at least, some considerable modification. I have, for many years, been devoting such thought and attention to the subject as circumstances would permit, and I now propose to submit my results to the public.

In the American Journal of Science and Arts, for September, 1852, the fact was noticed that, "if we commence with Neptune, the most remote planet known, we shall find that the primary

[10] Cambridge Philosophical Trans., vol. viii, p. 171.

planets are arranged in *pairs*, the members of which are nearly equal in diameter." Neptune and Uranus constitute the first pair; Saturn and Jupiter, the second; the asteroids and Mars, the third; the earth and Venus, the fourth; finally, Mercury is without a *known* companion. It was also remarked that in each of the three complete pairs, the first, second and fourth, the densities of the members are to each other very nearly as their volumes; and that the facts seemed to indicate "a similarity in the original constitution of the members of each pair, and an intimate mutual dependence or connection in their primitive condition." It appeared not improbable that in the first stages of their history, Neptune and Uranus constituted a system of closely associated rings; Saturn and Jupiter, another, &c., and that the law of planetary distances might be found in *the relative situations of the centers of gyration of those binary rings.* In short, my researches on the subject led to the hypothesis that *the differences of the radii of gyration of the primitive rings form a geometrical series;* or that

$$d_{(1)} = d_{(2)}k = d_{(3)}k^2 = d_{(4)}k^3 = \ldots = d_{(n)}k^{n-1};$$

where k = a constant;

$d_{(1)}$, $d_{(2)}$, $d_{(3)}$ ... &c., $= r_{(1)} - r_{(2)}$, $r_{(2)} - r_{(3)}$, $r_{(3)} - r_{(4)}$, &c., respectively;

$r_{(1)} = \left(\frac{D_{(1)}^2 + D_{(2)}^2}{2}\right)^{\frac{1}{2}}$ = the radius of gyration of the first pair, Neptune and Uranus;

$D_{(1)}$, $D_{(2)}$, &c. = the distances of Neptune, Uranus, &c., from the sun;

$r_{(2)}$, $r_{(3)}$, &c., = the radii of gyration of the successive binary rings;

Examination of this Hypothesis.

The values of $r_{(3)}$, k, and $D_{(5)}$ are thus computed: Having found

$$\begin{aligned} r_{(1)} &= 25{\cdot}20061 \\ r_{(2)} &= 7{\cdot}68305 \\ r_{(4)} &= 0{\cdot}87270 \\ d_{(1)} &= 17{\cdot}51756 \end{aligned}$$

we have the equations

$$r_{(3)} = \left(\frac{D_{(5)}^2 + (1{\cdot}5236923)^2}{2}\right)^{\frac{1}{2}} \qquad (1)$$

$$(7{\cdot}68305 - r_{(3)})\, k = 17{\cdot}51756, \qquad (2)$$

$$(r_{(3)} - 0{\cdot}87270)\, k = 7{\cdot}68305 - r_{(3)}, \qquad (3)$$

whence

$$\begin{aligned} k &= 3{\cdot}34189 && \log = 0{\cdot}5239916 \\ r_{(3)} &= 2{\cdot}44123 && \log = 0{\cdot}3876087 \\ D_{(5)} &= 3{\cdot}09800 \end{aligned}$$

This value of the distance of the asteroid planet is almost exactly identical with that found by my analogy.

The radii of gyration of the primitive rings, together with their differences, are as follows:—

$r_{(1)} = 25{\cdot}20061$	$d_{(1)} = 17{\cdot}51756$	$\log = 1{\cdot}2434736$
$r_{(2)} = 7{\cdot}68305$	$d_{(2)} = 5{\cdot}24182$	$\log = 0{\cdot}7194821$
$r_{(3)} = 2{\cdot}44123$	$d_{(3)} = 1{\cdot}56852$	$\log = 0{\cdot}1954906$
$r_{(4)} = 0{\cdot}87270$	$d_{(4)} = 0{\cdot}469350$	$\log = \bar{1}{\cdot}6714991$
$r_{(5)} = 0{\cdot}40335$	$d_{(5)} = 0{\cdot}140455$	$\log = \bar{1}{\cdot}1475076$
$r_{(6)} = 0{\cdot}26289$	$d_{(6)} = 0{\cdot}042026$	$\log = \bar{2}{\cdot}6235161$
$r_{(7)} = 0{\cdot}22086$	$d_{(7)} = 0{\cdot}012575$	$\log = \bar{2}{\cdot}0995246$
$r_{(8)} = 0{\cdot}20828$	$d_{(8)} = 0{\cdot}003763$	$\log = \bar{3}{\cdot}5755331$
$r_{(9)} = 0{\cdot}20451$	$d_{(9)} = 0{\cdot}001126$	$\log = \bar{3}{\cdot}0515416$
$r_{(10)} = 0{\cdot}20338$	$d_{(10)} = 0{\cdot}0003369$	$\log = \bar{4}{\cdot}5275501$
&c. &c.	&c. &c.	&c.
$r_{(\infty)} = 0{\cdot}20299$	$d_{(\infty)} = 0{\cdot}0000000$	$\log = -\infty$

Remarks.

1. The radius of gyration ($r_{(5)} = 0{\cdot}40335$) of the fifth primitive ring corresponds very closely with the mean distance of Mercury. This planet, therefore, according to the hypothesis, ought to be an exception to the binary arrangement. Such, in fact, appears to be the case. Or, if the planet originally existed as a binary ring, the mean distances of the members having the same ratio to each other as those of Venus and the earth, both must have been included between the present limits of Mercury's orbit. The union of the two rings and the formation of a single planet may thus have resulted from the eccentricity of the primitive annuli.

2. The sum of the infinite series

$$d_{(1)} + d_{(2)} + d_{(3)} + \&c., = \frac{d_{(1)}k}{k-1} = \frac{17{\cdot}51756 \times 3{\cdot}34189}{2{\cdot}34189} = 24{\cdot}99762;$$

and $25{\cdot}20061 - 24{\cdot}99762 = 0{\cdot}20299$ = the distance from the sun's center to the limit at which the separation of solar rings must have ceased. This is immediately exterior to the present limit of equilibrium between the centripetal and centrifugal forces.

3. The fifth radius of gyration, according to this hypothesis, exceeds the present mean distance of Mercury by the quantity 0·01626, or about $1\frac{1}{2}$ millions of miles. The corresponding difference in the period is about 5 days, or twice the amount by which the period of Encke's comet has been shortened in the last half century. Have the period and mean distance of Mercury been diminished, during the immensity of past time, from the same cause? Or may this slight and only exception to the strict accuracy of the law be referable to zones or groups of asteroids in the vicinity of Mercury's orbit, the existence of which has been indicated by the researches of Leverrier?"

[11] Runkle's Math. Monthly, vol. ii, p. 240.

4. The radius of gyration of the sixth primitive ring is 0·26289. This distance is nearly equal to that of Mercury's perihelion. Between this and the limit, 0·20299, the formula indicates the abandonment at the solar equator of an indefinite number of rings in close proximity to each other. The appearance of such zones or rings of nebular matter would be similar to that of the *zodiacal light*. This phenomenon was ascribed by Cassini to the blended light of an innumerable multitude of extremely minute asteroids revolving round the center of our system. Recent observations, it is true, have suggested the hypothesis that the appearance is produced by a *terrestrial* ring; but in opposition to this view, Prof. Barnard has adduced a number of weighty, if not insuperable objections. The greatest elongation of these rings of nebular or meteoric matter, when abandoned at the solar equator, would certainly be much less than that of the vertex of the zodiacal light; but is it not possible that, as in the case of several comets, the orbits of some may have been greatly changed by planetary perturbations?

Application to the Secondary Systems.

I.—THE SATELLITES OF SATURN.

The distances of the satellites of Saturn, in radii of the primary, are as follows:—

I.	Mimas,	3·1408
	Enceladus,	4·0319
II.	Tethys,	4·9926
	Dione,	6·399
III.	Rhea,	8·932
	———	
IV.	Titan,	20·706
	Hyperion,	25·029
	———	
V.	Iapetus,	64·359

This table is taken from *Loomis's Practical Astronomy*. The distances, we are informed by the author, "were derived chiefly from Mädler, modified in some instances by comparison with Herschel's Astronomy and Hind's Solar System." A chasm in the order of distances is observed between Rhea and Titan, and another between Hyperion and Iapetus—that is, immediately interior to the largest two members of the system. Now, as in the primary system the zone of asteroids occurs just within the powerful mass of Jupiter, supplying the missing term noticed by Kepler and Bode, is it not probable that similar *secondary* zones exist in those intervals? By interpolating these two satellites or asteroid zones, we obtain a series of ten terms, in which the eight known distances are represented *with perfect accuracy*. It is also remarkable that the limit of the ring-forming process,

according to this series, is precisely where Bond's ring is situated, between the body of the planet and the inner bright ring. The interpolated distances are 12·43 and 35·32 respectively. The radii of gyration of the pairs, together with their differences, are as follows:—

Names of Satellites.	Rad. of Gyr	Differences.
I. Mimas and Enceladus,	3·61	2·13
II. Tethys and Dione,	5·74	5·08
III. Rhea and ——	10·82	12·13
IV. Titan and Hyperion,	22·95	28·96
V. —— and Iapetus,	51·91	

These differences form a geometrical series whose ratio is 2·385. The sum of the series = 50·59, which substracted from 51·91 gives 1·32 as the limit. The series indicates the abandonment of an indefinite number of satellites or rings in close proximity to each other, between Mimas and this limit. Now Professor Vaughan has shown that neither a gaseous nor a liquid satellite, of considerable magnitude, would be stable so near the primary.[13] Hence the probable origin of Saturn's rings.

II.—THE SATELLITES OF JUPITER.

If we suppose the third and fourth satellites of Jupiter to have originally constituted one ring, or system of associated rings, the first and second, another, and that the ratio of the differences of the radii of gyration was the same as in the primary system, we shall find

$r_{(1)}$ = 21·960 equatorial radii of the planet,
$r_{(2)}$ = 8·036 " " "
$d_{(1)}$ = 13·924 " " "
$d_{(2)}$ = 4·166 " " "
$\frac{d_{(1)}k}{k-1}$ = 19·869 " " "

and 21·960 − 19·869 = 2·091 = the distance from the center of the primary, within which no rings could have been formed. This again is nearly equal to the distance (2·299) of the point of equilibrium between the centripetal and centrifugal forces.

But we discover no decided indications of the binary arrangement in the Jovian system. Is a similar relationship then to be found between the respective distances of the satellites themselves? "The four satellites of Jupiter," says Humboldt, "present a certain regularity in their distances, forming nearly the series, 3, 6, 12. The distance of the second from the first, expressed in diameters of Jupiter, is 3·6; the distance of the third from the second, 5·7; and that of the fourth from the third,

[13] Proc. Am. Assoc. for the Adv. of Sci., 1856, p. 111.

11·6." This would indicate a value of k for the Jovian system equal to 2; $r_{(\infty)} = 3$; and the possible separation of secondary asteroids between the limit 3 and the distance 4·5.

Our knowledge of the Uranian system is perhaps too imperfect to justify any conclusion in regard to the prevalence of a similar order.

In researches of this nature, the want of *exact* numerical verification ought not to be regarded as decisive evidence against the truth of an hypothesis. A partial deviation may be produced by the interference of some other law or arrangement. Of this we have innumerable instances in nature. Even the celebrated laws of Kepler, as commonly stated, are not strictly true; the mutual attractions of the planets producing endless perturbations.[13]

III.—The Mean Distances of the Periodic Comets, and their Relation to the Solar System.

The celebrated Laplace remarked that, according to the nebular hypothesis, "the comets do not belong to the solar system." He regarded them as small nebulæ which, wandering through space till they come within the sphere of the solar influence, enter our system from *without*, pass around the sun, and, unless influenced by the attraction of the planets, or the resistance of the ethereal medium, again pass off in parabolas or hyperbolas. Other astronomers believe them to have originated within the solar system. Perhaps each view may be partially correct. Several comets, among which we may instance that of June, 1861, have moved in hyperbolic orbits. These, together with many whose orbits seem to be parabolas, have probably entered the system *ab extra*. On the other hand, a large majority of *periodic* comets are believed to have originated *in* the system, and to belong properly to it. The author several years since called attention to the fact that there is an approximate coincidence between the planetary and cometary periods.[14] There are 13 known

[13] The idea of employing the radii of gyration of the planetary pairs, occurred to the writer in 1852. Various hypotheses involving this element were tested in the search for the law of distances; but the fact that the preceding formula gives the radius of gyration of the fifth planetary pair *greater* than the mean distance of Mercury, seemed, it was thought, sufficient ground for its rejection. At the Albany Meeting of the American Association for the Advancement of Science, in 1856, a paper was read by Professor Stephen Alexander, "On some Special Arrangements of the Solar System, which seem to confirm the Nebular Hypothesis." In this memoir, Professor A. likewise employed the radii of gyration of the planetary pairs; his method of using them, however, was different from the author's. This paper induced the writer to resume the subject. The applicability of a similar formula to the Saturnian system was regarded as confirmatory, and, finally, as it seemed possible to account for the slight inaccuracy in the case of Mercury, the striking conformity of the theory with facts has determined the author to submit his results to the public.

[14] Proc. Am. Assoc. for the Adv. of Sci., 1858, p. 10.

comets whose periods are included between those of Mars and Jupiter. Their motions are all direct; their orbits are less eccentric than those of other comets; and the mean of their inclinations is about the same as that of the asteroids. The perihelia of ♁ are exterior to the earth's orbit, and the nearest approach of Faye's to the sun is several million miles beyond the orbit of Mars. In fact, there is less difference between the eccentricity of the orbit of Faye's comet and that of some of the asteroids, than between the latter and that of some of the old planets; so that this body may be regarded as a connecting link between planets and comets. These facts appear to indicate some connection in their origin with the zone of asteroids.

Since the commencement of the present century, five comets have been discovered, which form, with Halley's, an interesting and remarkable group. The first of these was detected by Pons, on the 20th of July, 1812; the second by Olbers, on the 6th of March, 1815; the third by DeVico, on the 28th of February, 1846; the fourth by Brorsen, on the 20th of July, 1847; and the last by Westphal, on the 27th of June, 1852. The periods of these bodies are all nearly equal, ranging from 68 to 76 years; their eccentricities are not greatly different; and the motions of all, except that of Halley, are direct. The existence of these two cometary groups was noticed several years since both by Hind and Alexander. The latter supposes the cluster whose times of revolution are nearly equal to the period of Uranus, to have had a common origin. He infers from various facts that in the early part of the fourteenth century a large comet approached very near to Mars, if indeed there was not an actual collision between the two bodies. This ancient comet he supposes was thus separated into fragments. That most, if not all, of this cometary group have had a common origin, we regard as highly probable: we doubt, however, whether the true explanation of that origin has yet been proposed.

Again: the comet discovered by Peters on the 26th of June, 1846, has a period, according to the discoverer, of about 13 years; and Tuttle's comet (1858, I.) completes its revolution in 13·6 years. The perihelion of each is exterior to the earth's orbit, and their motions are direct. The periods of these bodies are a little greater than that of Jupiter. It may also be remarked that the comet which passed its perihelion on the 28th of November, 1793, has, according to Burckhardt, a period of 12 years. The period of the great comet of 1843 is probably nearly the same with that of Neptune. Other coincidences might be pointed out, but the periods in most cases are too doubtful to be relied upon. Those which we have adduced seem to point to an approximate coincidence between the mean distances of the planets and those of the periodic comets.

May not the exterior secondary rings, thrown off by the planets, have been at too great a distance to form *stable satellites?* and in such case would not the detached portions of matter revolve round the sun in very eccentric orbits, the degree of eccentricity depending on the direction of their motion at the epochs of separation from the secondary system? If so, the approximate coincidence between the periods of planets and comets would follow as a consequence.[15]

Indiana University, Bloomington, Indiana, March 29, 1864.

ART. II.—*Abstract of Prof. Meissner's Researches on Oxygen, Ozone, and Antozone;* by S. W. JOHNSON.

[Concluded from vol. xxxvii, p. 335.]

THE 2d Section, entitled *The Polarization of Oxygen in the Act of Combustion*, opens with an examination of the products of the slow oxydation of phosphorus. The white fumes which are always formed in this process have been the subject of much speculation. Schönbein observed that the fumes appear only in *moist* air. He once (1848) held them to consist merely of phosphorous acid, formed by the contact of vapor of phosphorus with oxygen. Afterward, he noticed that they do not readily disappear upon agitating with water, and since dry PO_3 absorbs water with great avidity, he assumed in the fumes the existence of an insoluble PO_3, isomeric with the ordinary acid. Williamson thought the cloud to consist of PO_5, the last result of the action of ozone on vapor of phosphorus. Osann, at first, denied the existence of any of the oxyds of phosphorus in the fumes on account of the permanence of the latter, as they may be passed through water, potassa lye, oil of vitriol, nitric acid, and solutions of nitrate of silver, arsenious acid, protosulphate of iron, and iodid of potassium, without perceptible change. Finding, however, evidence of the presence of PO_3 in the water over which the cloud had been allowed to stand until it disap-

[15] The perturbation of such portions of nebulous matter was the "general cause" to which the writer referred in his paper on the mean distances of the periodic comets, read before the American Association in 1858. Nearly the same idea was suggested in a letter dated May, 1863, by DAVID TROWBRIDGE, Esq., of Perry City, N. Y. At that time, Mr. T. knew nothing of the above-mentioned paper on the subject, so that the hypothesis was with him entirely original. He remarks:

"The breaking up of the ring might detach small portions that would not unite with the parent mass. The eccentricity would depend on the angle of projection. See *Math. Monthly*, vol. ii, p. 160, Art. 18, Equation (58).

"This being true, the mean distances of the comets should coincide approximately with the mean distances of the planets. I think we should look for the larger comets to have the longer periods of revolution, because larger amounts would be thrown from the large rings in a less condensed state."

peared, Osann adopted Schönbein's idea of the existence of two modifications of phosphorous acid.

Quite recently, as our readers are aware, Schönbein has given up his former opinions and now maintains that the cloud consists essentially of *nitrite of ammonia*. The objection with which he now argues the impossibility of its being constituted of phosphorous acid, viz: its insolubility in water, he does not appear to notice is equally fatal to this new idea.

Meissner, on subjecting a stream of air that had passed over moist phosphorus to the tests already detailed, obtained with it all the phenomena which characterize antozone. Thus, when the air is washed with solution of iodid of potassium, whereby it is deozonized and thereupon is made to pass through water, it emerges from the latter as a thick cloud. The cloud vanishes of itself after the lapse of about half an hour and cannot then be reproduced, though it is scarcely diminished by agitation for a short time with water; when subjected to drying agents, it disappears, but is formed again on renewed contact with water, if too much time is not allowed to transpire.

In the air which is acted on by phosphorus there thus appear both ozone and antozone, as in the case of electrized air; but the relative proportions of the two allotropic oxygens, in the air which has been conducted over moist phosphorus, are very different from what exist in electrized air. In the case of air exposed to moist phosphorus, the quantity of ozone is much less than in electrized air. This is due to the fact that the phosphorus itself consumes a large share of the ozone. Meissner obtained in his experiments much more antozone by phosphorus than by electricity, as measured by the density and ready appearance of the cloud.

While passage of the electrized air through strong solution of KI removed the cloud, by absorbing its moisture, it was found, as Osann had observed, that the phosphorus cloud was scarcely affected by bubbling through oil-of-vitriol. It is only needful, however, to prolong or increase contact between these drying agents and the cloud in order to cause its disappearance.

When the phosphorus cloud traverses a strongly heated glass tube, it disappears. The same is true when it is brought into intimate contact with PbO_2 or MnO_2.

By diminishing to a certain point the quantity of oxygen in a gaseous mixture, we may have the result, that when it streams over moist phosphorus, all the ozone produced is again consumed, and only antozone (of the two active forms of oxygen) remains in the air.

The complete identity of the cloud that forms when phosphorus slowly oxydizes in moist air, with that produced when electrized air emerges from water, is thus established.

Long ago, Schönbein observed that HO_2 appears when air is acted upon by moist phosphorus. This substance Meissner finds to be more largely and easily obtainable from air exposed to phosphorus than from electrized air. This he concludes to depend upon the corresponding difference in the relative development of antozone in the two instances. On the other hand, when the air from phosphorus passes through solution of KI, it yields to subsequent wash-waters but minute traces of iodic acid, while from electrized air this substance may be collected in considerable quantity. This fact is again to be ascribed to the small amount of ozone in the former as compared with the latter case.

In water which had been traversed by the air from moist phosphorus, previously deozonized by means of KI, no nitrous acid and no ammonia could be detected. Of the latter, at least only those minute traces everywhere recognizable with potassio-iodid of mercury, were observed.

The water, thus containing HO_2 but free from NO_3 and NH_3, contained PO_5. When the antozone cloud produced by phosphorus is received in a perfectly dry and clean vessel, and there allowed to resolve into ordinary oxygen and water, the latter, which deposits as a dew on the walls of the vessel, has an acid reaction, which is not attributable to the minute trace of IO_5 it contains, but proceeds from PO_5, whose presence is readily made out by the usual tests.

Even when the antozone cloud is made to bubble through potash-lye, it still retains a trace of PO_5. It is, in fact, the property of the antozone cloud to transport suspended matters, which accounts for the finding of PO_3 and PO_4 by other observers. It is of course only needful to procure sufficient contact between the antozone cloud and water, or an alkali, to arrest these substances entirely.

When the air clouded by contact with moist phosphorus is made to pass direct through water for a long time, the latter acquires an acid reaction from PO_5. After the PO_5 is removed, or neutralized, HO_2 may be detected by aid of KI, starch and $FeO\,SO_3$. Nitric acid Meissner found but very rarely and then in but very minute traces.[1] It appears that while in electrized air nitrogen is oxydized by the ozone to a considerable extent, in air streaming over phosphorus the phosphorus appropriates the ozone in great measure.

The results of the mutual action of phosphorus, air, and water are somewhat different, when, as in Schönbein's experiments, the air is allowed to stagnate over the phosphorus. In the phosphatic acid, as we may designate the solution which forms about the phosphorus in the ordinary ozone bottle, there are found

[1] So also Pugh failed to find NO_5 in similar experiments. "*On the Sources of Nitrogen to Vegetation.*" *Phil. Tr.*, 1861, Pt. II, p. 496.

PO_5 and PO_3, as has long been known; HO_2, as Schönbein discovered,[1] and likewise NO_5. As regards the last named substance, Meissner states that its quantity is but small, more of it being produced in one hour by his electrizing apparatus, than in 24 hours by phosphorus.

Schönbein has lately asserted the presence of nitrous acid and ammonia in the so-called phosphatic acid. The reactions on which Schönbein based the discovery of NO_3 are all, indeed, as he described them; but they all admit of a different explanation. The decomposition of KI by the phosphatic acid may be attributed to HO_2; and a more direct reaction must be employed in order to demonstrate the existence of NO_3. For this purpose Meissner freed the liquid of PO_5 and PO_3 by BaO, made it alkaline with KO, and, after suitably concentrating, examined it for NO_3 by means of $FeO\,SO_3$ and dilute SO_3. In a few instances he found minute traces of NO_3 by this method; but in no case was NO_3 present in the quantity that would be indicated by the KI and starch test. As regards NH_3, Meissner declares his inability to discover in the phosphatic acid more than the traces, which, as Faraday, Boussingault and others have taught us, are universally distributed on the surfaces of porous bodies and throughout the atmosphere.

Schönbein appears to place most reliance upon his experiments wherein a clean moistened sponge was used to absorb the vapors or cloud that is formed over phosphorus. He was perfectly right in asserting that the water obtained by squeezing the sponge after prolonged exposure, is neutral to test papers, but, nevertheless, strikes a deep blue color with acidulated solution of KI mixed with starch. Meissner assures us that this reaction is entirely attributable to a product of the action of ozone upon an ingredient of the organic matter of the sponge, viz: *iodine;* and that, on concentrating the water pressed from the sponge and adding to it sulphurous acid, a copious separation of iodine occurs. This reaction demonstrates that iodic acid, which decomposes KI with ease, gave the reactions from which Schönbein deduced the formation of NO_3 in the slow combustion of phosphorus.

In the examination of the so-called phosphatic acid, Meissner found evidences of the presence in it of another substance, possessed of reducing properties, opposed to the oxydizing quality of antozone. As previously observed, solution of pure KI, free from IO_5, when acidified, after some time suffers decomposition with separation of I, and the rapidity as well as the extent of

[1] And in very large quantity, compared with what is produced when the air is made to traverse water placed in another vessel. In the latter case, antozone which with water forms HO_2, is too far advanced in its reversion to the inactive state to produce its highest effect.

the decomposition are the greater the larger the quantity and the stronger the quality of the acid added. If, now, two equal portions of the same solution of KI, each acidified with a drop of the same dilute SO_3, are mixed, one with pure water and the other with the same volume of what remains of the phosphatic acid solution after it has been precipitated by CaO, it is seen that the separation of iodine is greatly hindered or entirely prevented in the latter case.

Further study of this liquid conducted to the result that it owes this reducing quality to ozone. In fact, when air ozonized by phosphorus or by electricity is allowed to stand at rest in a flask until all antozone has vanished, and then the flask washed repeatedly to remove all phosphatic acid or deposited matters, the ozone that remains communicates this property to pure water. *Ozone water*, as the liquid may be called, gradually loses its reducing quality when exposed to air or evaporated on the water-bath. Its properties are the opposite of those of HO_2, which we may term *antozone water*. Ozone water and HO_2 may exist together in the same liquid, and, under certain circumstances, the former prevents the oxydations which the latter, if alone, would accomplish. This reducing power of ozone water is only relative, and not an absolute and invariably exhibited quality. Meissner has found indeed no means of directly effecting oxydations by means of ozone water; but he has learned that in some cases it does not limit or counteract oxydizing influences. Solution of KI, as is known, is decomposed by PbO_2 with liberation of I. The oxygen of PbO_2 acts accordingly like ozone. This oxydation, so far from being hindered, appears to be promoted by ozone-water. Meissner's observations on this so-called ozone water are, however, confessedly incomplete.[3]

He recalls, however, a fact noticed twenty years ago by Schönbein, who found that water which had been agitated for a long time with a large volume of air ozonized by electricity, was electro-negative compared with pure water. Schönbein remarks that ozone is taken up by water to only a very slight extent, and its voltaic activity is extremely small. Antozone-water, i. e. HO_2, is electro-positive compared to water. Meissner has experimentally confirmed these observations.

The action of phosphorus, according to the author's view, consists "in polarizing the inactive oxygen. It operates like an electrically excited body, and since it combines with ozone, which is negative-active oxygen, it operates like a positively electrized body, or has the effect of electro positive tension. Phosphorus must produce this polarizing effect by virtue of what we designate its great chemical affinity."—p. 256.

[3] May not the reducing action which HO_2, as ordinarily prepared, is well known to exert upon many oxyds, be due to the same cause as was operative in Meissner's experiments? S. W. J.

"What we call the chemical affinity of phosphorus for oxygen is the same thing that is exerted in a less degree by zinc when it slowly oxydizes in moist air: the latter is, however, due to the same cause which results in the exhibition of negative electricity when zinc is immersed in water; the chemical affinity of phosphorus to oxygen is the *difference* in its attraction toward positive and negative electricities: affinity is strong because the difference in electrical attractions is great, because the attraction for negative electricity largely preponderates."—p. 256.

"If phosphorus polarizes the molecule of inactive oxygen (into the ozone and antozone atoms), it must exert a polarizing and separating influence upon the electricity of other bodies. This is really the case, as shown by Schönbein, whose observation I have found to be entirely correct. Schönbein discovered that when a plate of gold or platinum is immersed in vapor of phosphorus, or is rubbed over its surface with a stick of phosphorus, and dipped into water in contact with a clean plate of the same metal, it exhibits positive electricity. When phosphorus is placed in a bottle with moist air, it emits, at first, a garlic odor; and only afterwards, when some time has elapsed, does the odor of ozone become manifest. The garlic odor is evidence that unoxydized vapors of phosphorus occupy the bottle. If a platinum plate be suspended in these vapors, it is positively electrized; when, however, later, ozone predominates, the plate becomes negative."—pp. 266–7.

We have not space to give, in full, Meissner's interesting theoretical discussion of this topic, which occupies a number of pages of his book, but must confine ourselves chiefly to recounting the facts he adduces.

In the rapid combustion of phosphorus, Meissner remarks that ozone does not appear, being entirely consumed; but antozone is much more copiously produced than in the slow combustion. The fume yielded by phosphorus burning in moist air, though containing phosphoric acid, is the antozone cloud. Dry phosphorus, burning rapidly in dry air, gives a cloud consisting of phosphoric acid alone; but it is very different in aspect and permanency from that produced when the burning phosphorus floats on water within a bell-glass. If a bottle full of the cloud thus formed be briskly agitated after a little water has been introduced within it, the PO_5 is shortly absorbed; but the mist caused by antozone remains. When a current of air, charged with the products of the rapid combustion of phosphorus, is transmitted through strong potash-lye and then through water, the phosphoric acid is mostly retained; but the cloud is increased in quantity and density. Meissner detected no formation of HO_2 in this case.

Since all the ozone produced when phosphorus burns rapidly

is consumed by the phosphorus, no oxydation of nitrogen can occur, and, in fact, none of the oxyds of nitrogen are discoverable in the products.

It is known that phosphorus, burning with flame in a limited volume of air, does not wholly exhaust the latter of oxygen. This is due to the fact that phosphorus cannot combine with antozone, but only with ozone: when, therefore, the former alone remains, the combustion must cease. That nearly all the oxygen is nevertheless taken up by the phosphorus, results from the rapid reversion of antozone to ordinary oxygen at a high temperature, so that the same oxygen is probably polarized and depolarized over and over again, until the temperature so far falls that antozone acquires a considerable degree of permanency, when depolarization ceases.

At ordinary temperatures, phosphorus is capable of removing oxygen completely from the air, if *sufficient time* be allowed; i. e. if the antozone first formed be allowed to revert to common oxygen, which is again polarized, whereby half (?) of it is converted into ozone, which unites to the phosphorus, and this process repeats itself until all oxygen passes into combination, or until only a minute, and to our tests inappreciable, residue remains uncombined.

In the slow oxydation of turpentine and other volatile oils, it appears that oxygen is polarized, the ozone being completely absorbed by the oil, resin and other products resulting: while antozone, which does not oxydize the oil, remains free or is dissolved in it as HO_2. This view is sustained by the following experiments. When a stream of air is passed through freshly-distilled and pure turpentine, the latter is oxydized, as when exposed to air, but more rapidly; but no ozone can be detected. Antozone, however, is contained in the oxydized oil: at least, the latter gives, as Schönbein has shown, the reactions of HO_2. When electrized but deozonized air is transmitted through the oil, it is oxydized precisely as by a stream of ordinary air; the antozone produced by electrization being without effect. Ozone, however, oxydizes and resinifies the oil with extraordinary rapidity.

The same process doubtless occurs in the slow combustion of ether.

In case of zinc, both the ozone and antozone unite with the metal.

The combustion of hydrogen is a process which Meissner has likewise studied experimentally. Burning a jet of this gas under a bell-glass which is connected with an air-pump having intervening receivers, it is observed that when, by pumping, a rapid stream of air is carried along the flame and afterward through water, the antozone cloud is produced without difficulty.

There is no doubt, adds Meissner, that hydrogen, when exploded with oxygen by the electric spark, polarizes the latter substance; and Priestly has observed, in such an experiment, the formation of a dense white mist—the antozone cloud.

The formation of antozone in the combustion of hydrogen is proved, also, by the fact that HO_2 appears as a product. Böttger made the observation that the perfectly neutral water, obtained by burning pure hydrogen in the air, liberates iodine from slightly acidulated solution of KI, and likewise reduces an acidulated solution of KO, Mn_2O_7. Böttger (and Schönbein, also, on learning this fact,) was inclined to attribute these reactions to HO_2; but since the liquid retained these oxydizing and reducing qualities even after concentrating considerably at a boiling heat, and, moreover, gave Schönbein a negative result on applying his test (KI with FeO, SO_3), it was concluded by both these chemists that *nitrite of ammonia* is produced in this combustion; a conclusion which they both have since extended to all instances of combustion.

Meissner finds that in some cases the reactions described by Böttger are not obtainable with the water yielded by the combustion of pure hydrogen; but that when they are, the water, also, gives the reaction of HO_2 with Schönbein's test, provided too much FeO, SO_3 be not employed. Meissner further finds, by trial, that a dilute solution of HO_2 may be boiled a long time without losing its characteristic qualities; while NH_4O, NO_5 in solution is completely and very rapidly decomposed. *There remains, then, no ground whatever for the extremely improbable assumption that nitrite of ammonia is a universal product of combustion.*

The formation of the antozone mist and of HO_2 may be observed with any flame the same as with burning hydrogen, care being taken that the air which surrounds the flame, or is made to stream over it for the purpose of transporting these products into a suitable receiver, be not heated too strongly. The experiment succeeds easily with the alcohol-flame; but is difficult when a smokeless gas-flame is employed, on account of the high temperature of the latter.

The antozone produced in the vicinity of a flame is, in great part, destroyed again by the high temperature to which it is exposed, even when the flame is situated in the midst of a powerful current of air.

When the combustion is slow or smouldering, antozone appears in large quantities, and in presence of moisture forms the characteristic mist or cloud. Tobacco-smoke, according to Meissner, is a genuine antozone mist, though various products of combustion are suspended in it. When a cigar is "smoked" by an air-pump or aspirator, the larger share of these products of

combustion may be removed by means of suitable absorbents; but the mist remains undiminished, and by passing it through water is actually increased in density. Cold tobacco-smoke, when collected in a bottle, slowly disappears in a manner corresponding to that noticed in case of the antozone cloud obtained from electrized air. The water, which is an essential part of tobacco-smoke, comes partly from the tobacco itself, partly from the mouth of the smoker. It is a fact of common observation that the smoke which is blown from the mouth is much whiter and more opaque than that which curls from the end of the cigar, and by retaining smoke in the mouth for a time, its density is increased. The fact that tobacco-smoke may be passed through water, as in the nargile, without losing its odor or narcotic effect, is due to the property of the antozone cloud to suspend and transport solid matters, which has already been noticed. Such are Meissner's views, which certainly have very many probabilities in their favor, although they are not altogether without further need of experimental confirmation.

In the third and last division of this work, the author discusses the *Ozone and Antozone of the Atmosphere.* He first reviews the observations of Halley, Kratzenstein, Saussure, and Forbes, regarding the physical structure of mist, and confirms the fact of its vesicular nature. He next discovers by experiment that while it is easy to condense moisture from any moist gas or gaseous mixture by cold or rarefaction, *it is impossible to produce a mist unless the gas is oxygen, or contains this element.* The water condensed by artificial means from pure oxygen or from the atmospheric air always exhibits the character of a cloud; that, separated from other gases or mixtures free of oxygen, always assumes directly the form of rain. Where oxygen is present, the water condenses in *vesicles;* in other cases, in *solid drops.* Meissner states, further, that air saturated with moisture gives a cloud on sudden rarefaction until the pressure is reduced to about 8 inches of barometric pressure. At this levity the cloud is, however, extremely delicate and transitory, and under a less pressure no cloud could be produced. This stand of the barometer corresponds to a height in the atmosphere, above tide-level, of 27,000 feet. According to Kämtz, the lightest and highest clouds, *cirrhi*, are formed at an average altitude of 20,000, and a greatest altitude of 24,000 feet. The densest artificial cloud is formed in the densest air, and the heaviest *cumuli* are formed within 5,000 feet from the sea-level.

From these facts, Meissner proceeds to addúce arguments in favor of the view that all atmospheric clouds are really due to antozone, and consist of antozone in its union with water. We do not propose to follow the author through the details of his discussion of this physical part of his subject. We shall con-

fine ourselves to pointing out concisely the train of conclusions he has arrived at.

In examining the analogies that exist between the natural atmospheric clouds and the ozone-cloud of his experiments, Meissner finds that the same molecule of oxygen may exist in all of a series of conditions ranging from highly (positively) electrized oxygen (antozone), to ordinary inactive oxygen, in all of which conditions it is characterized by its hygroscopic quality. From the higher to the lower stages of antozonization it passes progressively and spontaneously, and the decline of activity, chemically or electrically speaking, is commensurate with its loss of hygroscopic capacity. It would appear, further, that the hygroscopic property of antozone is specially characterized by its producing the vesicular arrangement of the molecules of water.

That the atmospheric oxygen is always more or less mixed with antozone, or is in an antozone state, is shown, so Meissner reasons, by the results of observations on atmospheric electricity, which nearly always indicate the air to be somewhat positively excited.

Meissner here recounts the views formerly maintained by Saussure, Hube, Parrot, and others, but now abandoned, which attributed important offices to electricity in the formation of clouds. He further reminds us that fogs are always highly electro-positive, and the more so the denser they are, as Volta, Read and Schübler have observed. As regards clouds, which are nothing but fogs at an elevation, he finds that the mass of testimony leads to the conclusion that they, too, are positive.

The electrical state of the atmosphere thus favoring the assumption that it may contain antozone, we should expect to find direct evidence of the presence of the latter. Meissner has not indeed directly examined the rain of thunder storms for HO_2, but he reasons with much cogency that the reactions from which Schönbein has deduced the presence of nitrite of ammonia in rain-water may be attributable to HO_2, as we have already seen.

Evidence that antozone is produced by discharges of lightning, is not, however, wanting. The formation of a dense cloud that has been compared to tobacco-smoke, in the path or vicinity of a thunderbolt, is a matter of oft-repeated observation; and Schönbein himself has recorded two instances of this kind that fell under his notice: in one case his own house, and in the other a neighboring church, having been filled with an irritating vapor or cloud.

Meissner reviews the attempts to account for the positive electricity of the atmosphere, and in pronouncing them all failures, he puts in place of the question, "What is the source of atmospheric electricity?"—the inquiry, "What is the origin of anto-

zone—positive-electrized oxygen—in the atmosphere?" We see at once that the former question may be regarded as answered when the latter finds a satisfactory reply. Meissner considers himself warranted in assuming that what he has shown to be true in the combustion of phosphorus and hydrogen is typical of all processes of oxydation by atmospheric oxygen, and that, accordingly, this element suffers polarization in every instance where its affinities are exerted. "A bit of phosphorus with its immediate surroundings of air and water, in which it slowly burns, is a picture of the earth with its atmosphere and the oxydable substances, together with water, upon its surface: the white fumes which rise from the phosphorus (the solid matters held by them in suspension being disregarded) are not only chemically the same, as the fogs and clouds of the atmosphere, but the mode of origin of both is identical."—pp. 345–6.

Here we finish our imperfect analysis of this book; a book which we have studied with great satisfaction, both from the importance of the topics it discusses, and the philosophic spirit everywhere exhibited by the author. We are bound to say that the assumption of the formation of *nitrite of ammonia* from nitrogen and water is refuted by Meissner, and the true origin of the oxyds of nitrogen that occur in nature is satisfactorily explained. The ozone question by these researches acquires a broader basis and more consistent aspect than it has hitherto possessed, and the new fields of investigation that are displayed through these pages are full of invitation and of promise.

ART. III.—*On the Transparency of the Earth's Atmosphere;* by CLEVELAND ABBE.

BOUGUER in his *Traité d'Optique* and Laplace in his *Mécanique Céleste* have investigated the effect of the earth's atmosphere in absorbing the light of celestial luminaries. The latter has shown that, approximately, the logarithm of the intensity of their light varies inversely as the cosine of their zenith distance, and, more nearly, as the quotient of the refraction divided by the sine of the zenith distance.

If, then, assuming any unit of comparison, we observe the intensity i at the zenith distance θ, and the intensity I at the zenith distance zero, the intensity just before entrance into the atmosphere being put at i_0, we have,

$$\log \frac{i}{i_0} = \frac{\log \frac{I}{i_0}}{\cos \theta} = \frac{-Q.(\varrho).l}{\cos \theta}, \quad \text{or } \log E = \frac{\log E_0}{\cos \theta}, \qquad (1)$$

where $-Q$ is a constant to be determined, (ϱ) is the density of

the atmosphere at the time and place of observation, and l is the height of a homogeneous atmosphere of the density (ϱ).

Therefore we see that $\log E_0$ varies with the barometer and thermometer. For the more accurate formula we have,

$$\log \frac{i}{i_0} = \frac{\delta\theta}{\sin\theta}.\log\frac{I}{i_0} = -H.\frac{\delta\theta}{\sin\theta}, \quad \text{or } \log E = \frac{\delta\theta}{\sin\theta}.\log E_0, \qquad (2)$$

where $\delta\theta$ is the observed atmospheric refraction, and $-H$ a constant equal to $-\frac{n^2}{2K}.Q.l$.

This last formula depends on the assumption of a uniform temperature throughout the atmosphere, which assumption, says Laplace, can produce no great error. Therefore for the same place and standard height of the barometer and thermometer we should for all celestial luminaries have E_0 constant.

The numerical values of I and i_0 in terms of our assumed standard can be determined from two observations of i_1 and i_2 at the zenith distances θ_1 and θ_2.

To this end we have, adopting the approximate formula (1),

$$\log I = \frac{\cos\theta_1 \log i_1(\cos\theta_2 - 1) - \cos\theta_2 \log i_2(\cos\theta_1 - 1)}{\cos\theta_2 - \cos\theta_1}, \qquad (3)$$

$$\log i_0 = \frac{\cos\theta_1}{\cos\theta_1 - 1}\frac{\log i_1 - \log I}{} = \frac{\cos\theta_2}{\cos\theta_2 - 1}\frac{\log i_2 - \log I}{}. \qquad (4)$$

Bouguer has given, on pp. 79–81 of his *Traité*, the result of two observations on the brightness of the full moon, which he made at Croisic in Bretagne, as follows:

1725, Nov. 23d,	10h 30m	$\theta_1 = 70° 44'$	$i_1 = 1681$	}	times that of
" " "	15 0	$\theta_2 = 23 \ 49$	$i_2 = 2500$	}	4 standard candles.

Whence he deduces, p. 84, that this ratio $\frac{1681}{2500}$ is the loss due to the absorptive power of 7469 toises of air having the density of that at his place and time of observation. On the result of these two observations he bases the table on page 332, where we find that

$$E_0 = +0{\cdot}8123, \qquad (A)$$

which number is adopted by Laplace in the tenth book of his *Mécanique Céleste*.

As Bouguer's serial formula is not equivalent to our equation (1), I have repeated the computation by (3) and (4), and find

$$E_0 = \frac{I}{i_0} = \frac{2548{\cdot}1}{3127{\cdot}0} = +0{\cdot}8149, \qquad (B)$$

assuming of course the barometer to have been at 30 in. and thermometer 50° F. during the day.

On page 81, vol. xxxvi, of this Journal, will be found some observations which Mr. Alvan Clark has made, which will give

us a second determination of this constant. I was in hopes of securing a longer series of observations accompanied with a record of the barometer and thermometer, but these seem to be the only ones available for our present purpose.

Mr. Clark, by diminishing the apparent diameter of the sun until it is barely visible to the eye, thus determines its brilliancy in units of the brightness of a faint sixth magnitude star. However much his results may depend on the peculiarities of his method and the delicacy of his eye, yet we may fairly consider them as comparable among themselves.

We have then

1863, April 27, Boston M. T.

$18^h\ 40^m$	$\theta_1 = 73°\ 11'$	$i_1 = 783100$	}	times that of the
24 0	$\theta_2 = 28\ 14$	$i_2 = 1308000$	}	faintest visible star,

Whence we derive, assuming the barometer and thermometer to have been at standard heights,

$$E_0 = \frac{I}{i_0} = \frac{1347632}{1680904} = +0{\cdot}8017, \qquad (C)$$

The difference between the values B and C may be considered as due to the diurnal and other changes in the heights of the barometer and thermometer at Croisic and Cambridgeport; to the differences in the transparency of the atmosphere and the annual and diurnal changes in the same; and to the fact that Bouguer observed the moon at night, and Clark the sun by day, therefore, the different laws of variation of temperature in the strata of the atmosphere and the brilliancy of the atmosphere as illumined by these luminaries will introduce discordances. This latter is the most important source of error; the light which we must measure in observations of this nature being the sum of those rays which penetrate the atmosphere *plus* the light of the atmosphere as illumined by those rays which it absorbs. In respect to this point it is very important that observations be made on the stars, comets and moon, as well as the sun. Mr. Clark's two observations at $18^h\ 30^m$ and 10^m P. M. are interesting in this relation. They are as follows. Admitting a large circle of the illuminated air which surrounds the sun he finds,

April 27th	$18^h\ 30^m$	$\theta_1 = 75°\ 2'$	$i_1 = 1055360$	} times that of faint-
28th	0 10	$\theta_2 = 28\ 20$	$i_2 = 1574400$	} est visible star.

Treating these observations by equations (3) and (4) we find:

$$E_0 = \frac{I}{i_0} = \frac{1606041}{1858843} = +0{\cdot}8640, \qquad (D)$$

the rough agreement of which, with the values A, B, C, is due to the preponderating influence of those rays of the sunlight which penetrate the atmosphere.

It will certainly be interesting to make a more elaborate investigation of this subject and to examine also the transparency

of our atmosphere to the rays of heat and the chemical rays as well as to those of light. The importance of this matter in certain astronomical studies is not to be underrated; since we often notice the tendency to an erroneous estimate of the relative brilliancy of a comet's nucleus and its tail as seen through the evening twilight in the most interesting part of its orbit; also in investigations upon the form of our Milky Way based upon the number of stars visible to Herschel in his guages, or observed by Bessel and Argelander in their zones.

For the present we shall merely append a table of the computed values of E for the two values of E_0 given in (B) and (C), together with the corresponding values abstracted from the table given by Bouguer, p. 332. The 2d, 3d, and 4th columns give the E which results from assuming $i_0=1$. The 5th column contains the quotient $\frac{E}{E_0}$ for the value (C) of E_0.

θ	Bouguer's table.	Bouguer's observations.	Clark's observations.	Clark's observations.
0°	0·8123	0·8149	0·8017	1·0000
10	0·8098	0·8123	0·7990	0·9966
20	0·8016	0·8042	0·7904	0·9859
30	0·7866	0·7894	0·7746	0·9664
40	0·7624	0·7654	0·7494	0·9347
50	0·7237	0·7272	0·7091	0·8844
60	0·6613	0·6639	0·6428	0·8017
70	0·5474	0·5496	0·5241	0·6537
80	0·3149	0·3076	0·2801	0·3494
90	0·0006	0·0000	0·0000	0·0000

ART. IV.—*On the Distribution of the Dark Lines in the Spectra of the Elements;* by Prof. GUSTAVUS HINRICHS, Iowa State University.

As soon as I heard of the great discovery of Kirchhoff and Bunsen, I felt sure that the dark lines of the elements would prove to be distributed according to simple laws, and that these laws might lead us to a knowledge of *the relative dimensions of the atoms.* But it was only quite recently that I was enabled to study the distribution of these lines in its detail, Prof. Silliman Jr. having kindly sent me Kirchhoff's two memoirs. Yet I limited my investigation to the group of the alkaline earths and iron; for whatsoever is true for some elements will also be found applicable to the remainder of them; and besides Kirchhoff's measurements are not at all to be considered as final, neither does he give all lines that may be observed: so that the material at hand can justify only a *preliminary investigation,* to be completed and modified by more complete and more accurate observations.

As it is well known that some distinguished American experimenters are engaged in a more accurate and complete survey of the spectra, I thought it proper to give the results of this preliminary research in order that the remarkable laws here found as the essence of Kirchhoff's determinations might as soon as possible be further developed.

It might seem that such an investigation could not lead to definite results, since Kirchhoff's scale is entirely arbitrary and even changing. But within a small range equal differences on this scale must correspond to equal differences in wave length, for whatever the curve may be (we have found it to coincide with a parabola), representing the wave-length as a function of Kirchhoff's millimetre-scale, within such narrow limits the curve will coincide with its tangent. We must therefore first see whether the different *groups of lines* exhibit any order.

Commencing with the *Calcium-spectrum*, we find a group of lines near Fraunhofer's G. Representing the intensity by I, the scale-division by K, the successive differences by D, we find from Kirchhoff's table—

Group I, $d_1 = 5{\cdot}0$.

I.	K.	D.	*i*.	C.	E.
5*c*	2869·7			2869·7	·0
		5·0	1		
4*b*	64·7			64·7	·0
		10·0	2		
4	54·7			54·7	·0
		20·5	4		
5*c*	34·2			34·7	+·5

It is plain that the values of D are as 1 : 2 : 4; considering these ratios as intervals, *i*, and calculating from them and the difference the values C, which would correspond to a perfectly regular distribution of the lines, we obtain the error of this theoretical determination E = C − K, as given in the last column. We see, the error is almost nothing—the last one might easily be conceived as the result of the increased range. Hence we find that this group is very regular, having a principal difference of 5·0, or a simple multiple (here successive duplication) thereof.

The *second group*, stretching from 2653·2 mm. to 2605·8 mm., has a range of 47·4 mm., which appears to be rather large; yet we find (comparing lines of high and similar intensity, those of lower intensity not being uniformly given):

Group II, $d_2 = 2{\cdot}026$.

I.	K.	D.	*i*.	C.	E.
5*b*	2653·2			53·2	0·00
1*d*	(52·9)	14·4	7		
5*c*	38·8			39·02	+·22
4*c*	(38·5)				
3*c*	(7·1)				
		32·2	16		
5*c*	6·6			6·60	−·00
3*b*	(5·8)				

The intervals are not in any simple ratio, but closely approach to 1 : 2, yet the great range of this group does not authorize us to give great weight to it.

Group III, d_3=·75. A very bright group of small range.

I.	K.	D.	i.	C.	E.
4*b*	1533·1			33·2	+·10
		·6	1		
4*b*	32·5			32·45	−·05
		2·3	3		
4*c*	30·2			30·20	·00
		1·5	2		
5*c*	28·7			28·70	·00
		6·0	8		
6*c*	22·7			22·70	·00

These errors are certainly within the errors of observation. The intervals seem to be rather irregular, but combining the first two we have 4 : 2 : 8, or 2 : 1 : 4. The signification of such combinations will become apparent in the sequel.

Group IV, d_4=1·3.

I.	K.	D.	i	C.	E.
3*d*	1235·0			34·8	− ·2
		5·4	4		
4*c*	29·6			29·6	·0
		1·3	1		
2*d*	28·3			28·3	·0
		3·6	3		
5*d*	24·7			24·4	− ·3
		3·1	2		
5*d*	21·6			21·8	+ ·2
		2·4	2		
3*c*	19·2			19·2	0·0
		1·4	1		
5*d*	17·8			17·9	+ ·1

Group V, d_5=3·5.

I.	K.	D.	i	C.	E.
2*e*	894·9			895·4	+ ·5
		10·0	3		
4*b*	84·9			84·9	·0
		21·0	6		
5*b*	63·9			63·9	·0
		3·7	1		
3*d*	60·2			60·4	+ ·2

only having an error in the extremes.

Group VI, d_6=2·3.

I.	K.	D.	i	C.	E.
5*b*	740·9			40·8	− ·1
		4·0	2		
3*b*	36·9			36·2	− ·7
		5·2	2		
5*b*	31·7			31·6	− ·1
		2·7	1		
2*b*	29·0			29·3	+ ·3
		8·9	4		
2*c*	20·1			20·1	·0
		2·3	1		
2*b*	17·8			17·8	·0

The error of ·7 is considerable in regard to d_6 and in general; yet it will disappear if we combine the first two intervals, thereby at the same time obtaining the simple series 4 : 1 : 4 : 1, or showing the whole group to consist of two equal parts of 5, each again composed of 4 : 1. Besides, it must be observed that the line 36·9 is faint as compared to the inclosing ones, marking plainly a subdivision as intimated.

These numbers seem to justify our first law:

I. *The mutual distances of the different lines in each separate group are multiples of the smallest distance in such group.*

To proceed further, we must remember that Kirchhoff himself acknowledges that he did not map all the lines he saw; besides, we know that many lines have been discovered which he did not see. Now the intensity of a line is certainly a less important element than its place; hence it may be that some lines are mapped while corresponding ones are not. Thereby we are permitted to group several lines into one group which we will call a *physical combination*, since it consists entirely of actually observed lines. It would, on account of the above, likewise be proper to admit hypothetical lines, thus dividing a given interval into a *virtual combination;* but since such divisions are given by the numbers representing the interval, and since we desire to keep this part of our article entirely free from any hypothesis, it being our purpose to show just what the given facts mean—we will not make any further use of such virtual combinations; what is here said will be sufficient to make the experimenter look to those places of the spectrum which are pointed out by such combinations.

The six groups of the calcium spectrum show the following remarkable physical combinations:

Group I, interval: observed 1 : 2 : 4.

Group II, range too great, interval approaching the ratio of 1 to 2.

Group III, observed 1 : 3 : 2 : 8

physical 4 : 2 : 8, or 2 : 1 : 4

Group IV, observed 4 : 1 : 3 : 2 : 2 : 1

physical 4 : 4 : 2 : 2 : 1

or 4 : 4 : 4 : 1

Group V, observed 3 : 6 : 1

Group VI, observed 2 : 2 : 1 : 4 : 1

physical 4 : 1 : 4 : 1

or 5 : 5

These numbers show:

II. *The intervals in the different groups may be expressed in very simple numbers, as* 1, 2, 3.

Thus there is a very great harmony between the intervals of the same group. If this harmony is to be admitted as a physical fact, it must extend throughout the whole spectrum of an element. And if our notion of a physical group, as containing corresponding lines, is correct, these physical groups must have corresponding intervals throughout. We find from the preceding tables:

	Physical interval.
Group I, $d_1=5{\cdot}0$	$\Delta_1=2d_1=10{\cdot}0$
[" II, $d_2=2{\cdot}026$	$\Delta_2=5d_2=10{\cdot}13$]
" III, $d_3=\cdot75$	$\Delta_3=14d_3=10{\cdot}5$
" IV, $d_4=1{\cdot}3$	$\Delta_4=8d_4=10{\cdot}4$
" V, $d_5=3{\cdot}5$	$\Delta_5=3d_5=10{\cdot}5$
" VI, $d_6=2{\cdot}3$	$\Delta_6=4d_6=9{\cdot}2$
	$5d_6=11{\cdot}2$

Group II is enclosed in brackets, because its wide range made us exclude it in the preceding; besides $5d_2$ is but a virtual interval, not marked by actually known lines. Δ_6 is somewhat indeterminable; yet it probably is $4d_6$ on account of the differences between Kirchhoff's scale and the natural scale of wave-lengths being for this group considerable. The whole of the brilliant group III has been considered as Δ_3, it forming decidedly a natural group. The great approximation of the values of Δ, distributed over almost the whole range of the spectrum, seems to justify the following conclusion:

III. *The difference in wave-length between the corresponding lines in a group is the same throughout the whole spectrum.*

It will be borne in mind that we did not select the groups to lead to such a law, but that we here—as actually was the case in finding this law—simply took the physical groups before given.

Hitherto we have never compared greater intervals than $\Delta=10$, taken in different parts of the spectrum; for such the corresponding wave-lengths will prove very nearly equal throughout. But now we must farther compare not the range of a group but the interval separating the different groups. Evidently the single lines interspersed between the groups will have the same physical signification; they may prove to be the only yet known members of less intense groups.

Comparing the values of Kirchhoff's scale with the well known wave-lengths of Fraunhofer's principal lines, we found by a graphical interpolation the following reduction to wave-length for the various single lines or groups:

I.	K.	Wave length G.=0^{mm}·00042·91+	Differences if $\delta=8$.
Group I,	$28\frac{3}{10}\frac{5}{0}$	+ 0·0	
" II,	$26\frac{3}{0}\frac{3}{6}$	1·5 to 1·9	$=2\delta-\cdot1$ or $+\cdot3$
6*c*,	2058·0	5·7	$7\delta+\cdot1$
2*c*,	1832·8	7·4	$9\delta+\cdot2$
5*b*,	1627·2	8·9	$11\delta+\cdot1$
" III,	$15\frac{3}{2}\frac{3}{3}$	9·6 to 9·8	12δ
2*b*,	1443·5	10·5	$13\delta+\cdot1$
" IV,	$12\frac{3}{1}\frac{5}{8}$	12·8	16δ
3*c*,	1029·3	15·4	$19\delta+\cdot2$
" V,	$8\frac{2}{6}\frac{5}{0}$	19·7	$25\delta-\cdot3$
" VI,	$7\frac{1}{1}\frac{1}{8}$	22·3	$28\delta-\cdot1$
2*b*,	641	23·0	$29\delta-\cdot2$

Greater degree of accuracy can not be attained before we have direct measurements of these wave-lengths like those recently made by Eisenlohr. The existing facts give these differences as multiples of $\delta = \cdot 8 = 0^{mm} \cdot 000008$ between the different *groups* of lines.

The intervals appear not very regular, but smallest (equal to δ) near the brilliant group III. Extending our view of physical combinations (i. e., such as are marked by actually known lines) to the whole of the spectrum, we obtain the following intervals:

Observed,	2	: 5 :	2	; 2 :	1	:	1	; 3 :	3	: 6 : 3 : 1
Physical,	2	: 5 :		6		:	6	:	6	: 3 : 1
or		7	:	6		;	6	:	6	; 4

both of which are almost as simple as possible. The latter would be formed of equal intervals, 6, if the last interval extended beyond 641 mm. K, and if some line should be discovered within the last observed interval, i. e., about midway between 2650 and 2840 mm. K. Hence the existing observations make it very probable that

IV. *The principal corresponding lines or groups of lines are equidistant* in regard to their wave-lengths.

It will be perceived that these successive laws may be considered as generalizations of the same principle. Hence it is of the utmost importance to see how far other substances give evidence of the same laws. We will first consider the other alkaline earths.

The spectrum of *strontium*, as given by Kirchhoff, is too deficient yet to be of any consequence.

The *barium* spectrum is more complete, but we have too few lines to discern the physical groups; therefore it seems best to rely on the more intense lines as corresponding ones.[1] We obtain as before:

I.	K.	G=0^{mm}·00042·91+	Differences.
1*b*	2502·4		
4*c*	·2		$\delta = 1 \cdot 1$
6*b*	2461·2	2·8	
2*c*	2031·1		$3 \cdot 4 = 3\delta + \cdot 1$
6*c*	1989·5	6·2	$4 \cdot 8 = 4\delta + \cdot 4$
1*b*	1371·4	11·0	
1*c*	1287·5		$1 \cdot 1 = \delta$
3*b*	1274·2	12·1	$2 \cdot 2 = 2\delta$
2*a*	1083 0	14·3	$1 \cdot 1 = \delta$
2*a*	1031·8	15·4	
1*b*	890·2		$3 \cdot 1 = 3\delta - \cdot 2$
4*b*	874·3	18·5	$1 \cdot 3 = \delta + \cdot 2$
3*a*	719·6	19·8	
2	718·7		

[1] Except where single lines occur in great distances, for they probably represent the more intense ones of those parts.

Giving the intervals

Observed,	3	:	4	:	1 : 2 : 1	:	3	: 1
Physical,	3	:	4	:	4	:	4	

These numbers thus confirm the conclusions drawn from the calcium spectrum. At the same time there appears yet one most remarkable new relation if we compare the interval 4δ of barium, which interval seems to be a physical one, with the corresponding interval 6δ of calcium. For we have

Calcium,	$\delta = \cdot 8$	hence	$6\delta = 4\cdot 8$
Barium,	$\delta = 1\cdot 1$	"	$4\delta = 4\cdot 4$

or only a difference of $0^{mm}\cdot 000004$ in wave-length between numbers as large as $0^{mm}\cdot 00005$. Is this physical interval for calcium actually the same as that for barium? Only more accurate observations can decide it; but if it proves equal, very great consequences will flow out of it.

The *magnesium* spectrum is represented by Kirchhoff as but one brilliant group. We have:

I.	K.	D.	*i*	C.	E.
6*e*	1655·6	6·8	1	55·8	+ ·2
6*f*	48·8	14·1	2	48·8	0·0
4*c*	34·7			34·8	+ ·1
6*g*	34·1				

showing $d = 7\cdot 0$ and conform to the first and second laws (I. and II).

Thus the four laws, first found for the calcium spectrum, are true for all the members of the group of alkaline earths, as far as their spectra are known. From this we conclude that they are essentially correct for all elements. How far this generalization is warranted we will now test by one of the most remarkable spectra: the brilliant and rich spectrum of *iron*, especially the three great groups of lines in this spectrum, groups almost without parallel both in regard to range, intensity, and closeness of the lines. Using the same signs as before, we have:

Iron, *Group* I, $d_1 = \cdot 8$, $\Delta_1 = 7d_1 = 5\cdot 6$.

I.	K.	D.	*i*.	C.	E.
4*b*	1200·6	6·7	8	1200·6	0·0
5*g*	7·3	10·5	13	7·4	+ ·1
5*d*	17·8	13·5	17	17·8	·0
5*d*	31·3	8·6	11	31·4	+ ·1
4*a*	39·9	2·7	3	40·2	+ ·3
6*c*	42·6	3·0	4	42·6	·0
4*d*	45·6			45·8	+ ·2

Intervals, observed,	8	:	13 : 17	:	11 : 3	: 4
physical,			21	:	28	: 7
or,			$3\Delta_1$	:	$4\Delta_1$	: Δ_1

thus having the simple ratio 3 : 4 : 1, and giving the physical difference $\Delta_1 = 7d_1 = 5{\cdot}6$.

Group II, $d_2 = {\cdot}8$, $\Delta_2 = 7d_2 = 5{\cdot}6$

I.	K.	D.	*i.*	C.	E.
4*d*	1337·0			37·4	+ ·4
		6·5	8		
6*c*	43·5			43·8	+ ·3
		7·6	9		
5*d*	51·1			51·0	− ·1
		1·6	2		
5*b*	52·7			52·6	− ·1
		10·2	12		
5*b*	62·9			63·0	+ ·1
		4·1	5		
6*d*	67·0			67·0	0·0
		5·6	7		
5*b*	72·6			72·6	0·0
		7·9	10		
4*c*	80·5			80·6	+ ·1
		4·2	5		
4*c*	84·7			84·6	− ·1
		4·7	6		
6*c*	89·4			89·4	0·0
		1·5	2		
5*d*	90·9			91·0	+ ·1
		6·6	8		
5*c*	97·5			97·4	− ·1
		4·1	5		
4*c*	1401·6			1401·4	− ·2
		8·9	9		
4*c*	10·5			10·2	− ·3
		11·0	14		
6*c*	21·5			21·4	− ·1
		1·5	2		
5*b*	23·0			23·0	0·0
		2·4	3		
5*b*	25·4			25·4	0·0
		2·8	3		
5*b*	28·2			27·8	− ·4

As starting point for C we made E=0 for the principal lines in the middle of the group, i. e., 67, 6*d*; and 89, 6*c*. Around these lines E are very small, but one extremity ΣE is positive, on the other negative: thus plainly indicating that the greater values of E are due to the great range—almost 100 mm. K—of the group, a range so great that the wave-lengths can not throughout fully correspond to the values K on Kirchhoff's scale.

As to the intervals, they again seem at first sight to be very capricious; yet we find

i, observed, 8 : 9 : 2 : 12 : 5 : 7 : 10 : 5 : 6 : 2 : 8 : 5 : 9 : 14 : 2 : 3 : 3

physical, 17 : 14 : 22 : 21 : 14 : 14 : 8

or, $2\Delta_2 + 3d_2 : 2\Delta_2 : 3\Delta_2 + d_2 : 3\Delta_2 : 2\Delta_2 : 2\Delta_2 : \Delta_2 + d_2$

the extremities of which series may be adjusted by extending the observation, thus giving

$$3d_2 + 2\Delta_2 : 2\Delta_2 : 3\Delta_2 + d_2 + 3\Delta_2 : 2\Delta_2 : 2\Delta_2 : \Delta_2 + d_2,$$

a symmetrical series of $7\Delta_2$, on each side of the median d_2, and on the left $3d_2$, on the right $\Delta_2 + d_2$ or $8d_2$; yet it may be that further observations will reduce the great interval $22d_2$ to $21d_2$ and thereby simplify the series. We must accept the observations at hand, and these show that $\Delta_2 = 7d_2$ is the physical difference of this group, and that these divisions of higher order are again simple, symmetric in regard to the middle of the whole group. It will be noticed that not only $\Delta_2 = \Delta_1$, as ought to be, but that even $d_2 = d_1$.

Group III, $d_3 = \cdot 9$; $\Delta_3 = 3d_3 = 2 \cdot 7$.

I.	K.	D.	i.	C.	E.
5*c*	2001·6			2001·6	0·0
		3·6	4		
6*d*	5·2			5·2	·0
		2·0	2		
6*c*	7·2			7·0	− ·2
		33·9	38		
6*c*	41·3			41·2	− ·1
		·9	1		
6*b*	42·2			42·1	− ·1
		15·8	18		
6*c*	58·0			58·3	+ ·3
		8·2	9		
5*c*	66·2			66·4	+ ·2
		·9	1		
5*c*	67·1			67·3	+ ·2
		14·9	17		
6*a*	82·0			82·6	+ ·6

The great value of the last E undoubtedly is caused by the great range of the last interval at the end of a great group; all the other values of E are very small.

The intervals are

Observed, $\underbrace{4 : 2}_{6} : \underbrace{38 : 1}_{39} : 18 : 9 : \underbrace{1 : 17}_{18}$

Physical, $6 : 39 : 18 : 9 : 18$

or, $2\Delta_3 : 13\Delta_3 : 6\Delta_3 : 3\Delta_3 : 6\Delta_3$

and these intervals of second order,

$$\underbrace{2 : 13}_{15} : \underbrace{6 : 3 : 6}_{15}$$

give further

thus again a symmetric division—here into equal parts—of this great group.

The value of Δ_3 differs considerably from $\Delta_1 = \Delta_2$; but it is obvious that $2\Delta_3 = 5 \cdot 4$ is almost the same as $\Delta_1 = \Delta_2 = 5 \cdot 6$.

These most magnificent groups of the elementary spectra thus fully confirm the four laws deduced from the calcium spectrum and extended to the alkaline earths. Hence we may conclude that those laws, in substance, will be found applicable to all elementary spectra. But until much more rich and accurate measurements, combined with direct determinations of wave-length, have been made, a further prosecution of this investigation will be useless; we therefore content ourselves with this preliminary research, hoping that future investigations based upon richer material will extend these laws, and by dividing the larger intervals, prove that these remarkable lines are not distributed at random but as regular as the stripes produced by diffraction.

As far as the observations are now at hand, the above four laws seem to point to the following one, including them all:

The dark lines of any element are regularly distributed over all the spectrum, in equidistant groups consisting of equidistant lines; but the intensity of these lines regularly increases and diminishes, so as to obliterate a number of lines and even of groups, thus producing gaps in the regular series, gaps which only by high optical powers—intense line of light and great condensing lens—can be completed.

Such observations therefore are most ardently desired, and it seems urgent to construct telescopes for this particular purpose.

If we, in the preceding, have succeeded in making the regularity of the apparently highly irregular lines probable—for they certainly show definite and simple laws in their distribution—it may naturally be asked: what *causes* this distribution, and what will probably be the reward of continued researches in this direction?

The lines can only have one of the following two sources. They are either produced by the dimensions of the solid particles or by the intervals between them, i. e., their distances. The latter is impossible, for these lines remain absolutely the same under such different circumstances as cannot but to some extent change the mutual distance of the particles. *Hence the lines must be produced by the bulk of the particles or atoms themselves, and an exact knowledge of these laws and distances must lead us to a knowledge of the relative dimensions of the atoms*, both as to length, breadth, and thickness. Thus optics will give us the form and size, as chemistry has given us the weight of the atoms. The remarkable result attained by comparing the distance between the calcium groups (4·8) and the barium groups (4·4) seems to show that *one dimension* of the atoms of these two elements is nearly—or if the above values should be found to be exactly equal—perfectly equal. How great the interest of such determinations is in regard to the constitution of the elementary bodies needs not to be accentuated. It may yet lead to an experimental demonstration of the existence of a primitive substance, the element of the elements.

How the dimensions of the atoms produce these lines is another question, and it is very difficult even merely to suggest any probable connecting link between the dimension of the atoms and the luminous wave. But this can not be any serious obstacle to the practical application to *the analysis of the elements:* for so the alkalies were decomposed by electricity although the causal connection manifested therein is but imperfectly known even at the present day.

But, however this may be, we hope those physicists who are favored by the necessary delicate apparatus will find in this unpretending preliminary investigation sufficient inducement to test—and as we think probable—to confirm and complete the result here deduced from the existing observations, that: *the dark lines of the spectra of elementary bodies are regularly distributed.*

Iowa City, March, 1864.

ART. V.—*On the structural characters of the so-called Melanians of North America;* by Dr. WM. STIMPSON.

IN the very interesting series of lectures on the Mollusca, by Dr. P. P. Carpenter, recently published by the Smithsonian Institution, under the heading of "Fam. Melaniidæ" the following passage occurs: "It is much to be regretted that American collectors, who have not been slow to avail themselves of the exuberant riches lying at their feet, which are so acceptable to European naturalists, have so generally entirely neglected the preservation and study of the opercula; and that so many points in the physiology and habits of these easily-observed animals have not yet been made known."[1]

There is only too much of truth in this remark. Not only "American collectors," but American naturalists, have been hitherto content with describing, from the shell alone, the multitudes of species of Melanians which swarm in our fresh-water streams and lakes, without any attempt to acquire a knowledge of the structure of these animals, or to determine the relations of the large and important group to which they belong. We are aware that several descriptions of the "animal" of certain species have appeared, but all of these are for the most part confined to characters of a trivial nature, such as color and proportions, while other characters, of paramount importance, have been overlooked or misinterpreted, though sufficiently easy of observation.

Indeed, as far as I am aware, no one has hitherto studied these animals sufficiently even to determine the primary characters of their sexual system: whether they are hermaphrodites, or have the sexes distinct; and, in the latter case, how the male may be distinguished from the female. And it is only by the recent publication of the invaluable work of Dr. Troschel, of Bonn, the "Gebiss der Schnecken," that we have been made acquainted with the nature of the lingual dentition of any members of the group.

My attention has been drawn to these animals incidentally while studying the characters of our North American *Amnicolæ*, and I will present here the results of the few observations which limited opportunities have enabled me to make upon two species inhabiting the waters of the Potomac River, namely, the *Melania virginica* of Say, and the *Mudalia dissimilis*[2] of Haldeman. These two species, though very distinct in the form of their shells, are so similar in the other characters of the animal

[1] Smithsonian Report for 1860, p. 206.

[2] The following appear to be synonyms of this species: *Paludina dissimilis* Say, *Anculosa nigrescens* Conrad, *A. dentata* Couth., *A. carinata* DeKay, and *A. trivittata* DeKay. All these forms are found living together in the Potomac above "Little Falls," and the exact similarity of the soft parts of the animal, in pattern of coloration, etc., in all of them, leads me to regard them as specifically identical.

that I am convinced that they cannot be separated generically upon other than conchological grounds. The same is true with regard to some other genera of the family, in which even the lingual dentition does not present distinctive characters of generic importance. But let it not be understood from these remarks that I deny the convenience and expediency of keeping separate as genera these groups founded on the characters of the shell. As long as our nomenclature is binomial and not trinomial, every well-marked group of species should be kept distinct as a genus, however trivial in importance the characters upon which it is based may seem to be; and this is all the more necessary in families containing a very large number of forms. A genus is simply the ultimate subdivision of species considered in respect to their relations to each other, and the elimination of the term "subgenus" from our categories seems to be required by the very nature of our binomial nomenclature.

The following brief account of the structural characters of the two Melanians above-named has no pretension to completeness, but is presented for the purpose of drawing attention to certain details of greater or less importance: with the hope that those who have materials at hand may be induced to follow out the train of investigation thus commenced, and particularly to make a thorough study of the sexual physiology of the group, which must prove of great interest in its diversity from that of ordinary Ctenobranchiate Gasteropods, as is indicated by the diverse character of the external sexual organs.

General Characters.—Head.—The head is provided with a rather large and somewhat elongated rostrum, tapering very little, and projecting normally considerably beyond the anterior margin of the foot. This rostrum or snout possesses considerable mobility, and has a strong resemblance in physiognomy to that of a hog, of which one cannot fail to be reminded while watching a crowd of these Melanians feeding at the river margin. It is somewhat contractile, and is wrinkled transversely upon the upper surface, except when protruded to its full extent, when the wrinkles disappear. In the living animal it is but little depressed, but it becomes much flattened in spirits. It is terminated by the oval disk, which is emarginated at the middle in front and behind; the mouth is indicated by a longitudinal slit at the centre, extending nearly to the posterior margin. The buccal mass is very little retractile, and its retraction is not accompanied by any invagination of the extremity of the rostrum. The jaws, according to Troschel,[3] consist of very numerous little scales, which have a polygonal, and for the most part a hexagonal, form. The teeth on the lingual ribbon are arranged in seven rows, (3, 1, 3), and their characteristics, according to the author above quoted, (whose observations on this point I have in part repeated,)

[3] Gebiss der Schnecken, i, 109.

consist in the form of the rhachidian tooth or plate, which is broader than long, rounded behind, and more or less sinuated anteriorly; the intermediate plate is of a rhomboid form, with a produced postero-exterior angle; and the inner lateral plate has fewer denticles at its extremity than the outer one. The tentacles are of moderate but variable length, tapering, and more or less pointed at their extremity. The small black eyes are situated on slight protuberances at the outer bases of the tentacula.

Foot.—The foot is short and thick, usually much shorter than the shell, truncated but not distinctly auricled in front, and rounded behind. The operculigerous lobe is conspicuous, and bears a corneous subspiral operculum of very few whorls, (generally only one), the nucleus of which, as was first observed by Professor Haldeman, is often broken off in adult individuals. In this case the operculum becomes elongated, projects beyond the posterior margin of the foot, and resembles that of the marine genus *Fusus*. On the right side of the body there is an impressed line, commencing at the bottom of the pallial cavity and running parallel to the median line of the back, until it curves downward behind the right tentacle, and reaches nearly to the margin of the foot.

Pallial cavity.—The margin of the mantle is simple in the species which have been examined, and probably so in all. At the right side of the opening of the pallial cavity it is slightly folded or sinuated, forming an afferent canal for the passage of water to the gills. The duct of the generative organ lies along the right side of the pallial cavity, in the angle formed by the juncture of the mantle with the back, and consists of two rather broad, unequal laminæ lying close against each other. Its base of attachment is narrow, and the outer edges of the laminæ are thin and sharp. Anteriorly, they taper gradually to their termination, near the aperture of the pallial cavity and close to the anus, where there is no free projecting extremity of the duct such as occurs in most Ctenobranchiata. I have been unable to discover any opening in either lamina at this point, so that the generative products are probably discharged from the inner surfaces of, and *between*, the laminæ, which conduct them like a channel toward the external element. The rectum lies in the usual position, parallel with and close above (to the right of) the generative duct. The fæces are not voided in a continuous worm-like cylinder, as in many gasteropods, but the cylinder is divided transversely, in the rectum, into sausage-shaped sections.

Branchiæ.—The gills, as in most other Ctenobranchiates, are two in number, lying upon the inner surface of the mantle. The principal or comb-like gill[4] is much elongated, extending to the

[4] It is difficult to imagine upon what H. & A. Adams base their character of the gills of the Melaniidæ,—"gill composed of rigid, *cylindrical plates*." (Gen. of Recent Moll., i, 293.) The italics are my own.

bottom of the pallial cavity. Its width anteriorly is about two-thirds that of the rostrum, but it becomes gradually narrower posteriorly. It consists of fifty or more thin triangular laminæ, the height of which is less than their length at the base of attachment. The supplementary or feather-shaped gill[6] is rudimentary, reduced to the simple mid-rib, which forms a short, linear, fleshy ridge between the left commissure of the mantle and the base of the principal gill, to which it is parallel.

My specimens are not in sufficiently good condition to enable me to trace the position of the mucus-gland (the "organ of viscosity" of Cuvier) and its aperture.

Sexual differences.—The Prosobranchiate Gasteropods are distinguished as an order from the Pulmonates and Tectibranchs, by having the opposite sexual organs in different individuals, instead of existing together in the same individual. Prior to the more recent investigations into the structure of the genital system in this order, the animals of a considerable number of the families composing it were supposed to be hermaphrodites. For example, Cuvier states that the sexes are united in the mollusks composing his orders Scutibranchiata, Cyclobranchiata, and Tubulibranchiata. And even some of the most recent authorities still continue to regard some of these animals as hermaphrodites. Carpenter, in his "lectures," published in 1861, says that in the order Scutibranchiata (in which he includes the Trochidæ, Turbinidæ, etc.) "the arrangements for the continuance of the species, instead of being separated on different individuals, are united in the same individual, which is supposed to be capable of self-impregnation."[8] And Moquin-Tandon, in his work on the terrestial and fluviatile Mollusks of France, and in a special article, describes an organ in the generative apparatus of *Valvata*, which he considers to be an hermaphrodite gland.[7] So there are said to be hermaphrodite Littorinæ, etc.

But the Trochidæ and Turbinidæ and all of the Scutibranchiata are now known to have the sexes distinct; that the same is the case in the Cyclobranchiata, has been shown by R. Wagner[9] and Milne Edwards;[9] and that the Tubulibranchiata are not hermaphrodites, has been established by the observations of von Siebold[10] upon *Vermetus*, the exactitude of which has been

[6] It should here be remarked, however, that the function of this organ is a matter of controversy. Some have considered it a color gland. But it has been generally regarded as a supplementary gill; and in those genera in which it is most largely developed, as *Buccinum*, *Natica*, and *Cypræa*, it certainly has a branchiiform structure. I am inclined to regard it as a true gill, homologous with the right gill of *Haliotis*, which has the same structure and apparently the same normal position, if we may regard the pallial cavity as tubular, and revolved a little to the left.

[7] Smithsonian Report for 1860, p. 211.

[8] Journal de Conchyliologie, iii, (1852), 244.

[9] Froriep's Neue Notizen, vol. xii, No. 249, (1839), p. 98.

[9] Annales des Sciences Naturelles, [2], xiii, (1840), 376.

[10] Vergleichende Anatomie der wirbellosen Thiere, (1848).

recently confirmed by Lucaze-Duthiers.[11] Indeed, wherever the generative organs of any of the Prosobranchiates have been submitted to a thorough examination, the sexes have been found to be distinct, and it may now be considered safe to conclude that they are so in all of them.

In the groups to which the Melanians have been supposed to be nearly allied, hermaphrodism has never been suspected. In *Rissoa*, *Amnicola*,[12] *Viviparus*, etc., the sexes are easily distinguished, the male being provided with a large and conspicuous external organ of generation, usually projecting separately from the side of the body behind the right tentacle, but in one group (the Vivipari) united to that tentacle, giving to it much greater thickness than occurs in the opposite one. In view of these facts, the occurrence of a copulatory organ in the Melanians also might well have been expected. Yet I did not succeed in finding it in any of my specimens; and the best endeavors to discriminate the sexes by dissection of the internal organs of generation were baffled by their similarity in all individuals, until the microscopic test was applied, when all doubts were removed by the discovery of ova in that organ in some individuals, and of spermatic particles in others, while the two were never found together; proving the organ in one case to be an ovary, and in the other a testis. The form of the spermatic particles in *Melania virginica* is nearly represented in fig. 1; the tails should be more slender.

1.

The fact being thus ascertained that the sexes are distinct in these animals, notwithstanding the agreement in form of the respective organs of generation, and the absence of a copulatory organ in the male, search was made for some external character by which the sexes might be distinguished, and it was shortly found that all those individuals in which the genital organ contained ova, had a conspicuous slit or sinus in the right side of the foot, about midway between the tentacle and the operculigerous lobe; while in those in which the organ contained spermatozoa, this sinus was entirely absent. Fig. 2 illustrates the position of the sinus in the female of *Mudalia dissimilis*.

2.

The female Melanian, then, may be distinguished from the male by the presence of this sinus. It consists of a deep pit on the impressed line mentioned in the description of the body and foot, from which a canal, formed by a fold of the superior parieties of the pedal muscles, extends downward nearly to the margin of the pedal disc. My observations have not extended far enough to enable me to ascertain

[11] Ann. des Sci. Nat., [4], Zool., xiii, (1860), 209.

[12] *Amnicola* has even been included in the family Melaniidæ by Lea. (Observations on the genus Unio, etc., vol. ix, (1862), p. 40).

the function of this lateral sinus; but from its occurrence in the female only, it is undoubtedly connected either with the fecundation, or the deposition, of the eggs. Before discovering it to be a sexual character, I had supposed this sinus to be connected with the water-circulatory system, and to be a water-pore like that seen in the pedal disc of *Conus* and the higher Gasteropods generally; this view having been favored by the fact that a strong and regular pulsation at the margins of the sinus may sometimes be observed in the living animal.

In view of these remarkable characters of the sexual system, the Melanians (the American species, at least,) must be separated from the ordinary Ctenobranchiate Gasteropods as a group of far more than family importance; for by the entire absence of an intromittent organ in the male, which must be connected with a very peculiar, and as yet unknown, method of impregnation, they diverge greatly from the other families of the group, and approach the Cyclobranchiata. Von Siebold indeed proposed to divide the entire order of Prosobranchiata into two sections, in one of which the copulatory organs are wanting (Cyclobranchiata, Scutibranchiata, (Cuv.) Tubulibranchiata, and Cirrobranchiata), while in the other they are highly developed.[13] Such a subdivision is, however, forbidden by the affinities shown by the sum of all the other characters of the animals under consideration, while at the same time the character so prominently brought forward by von Siebold has undoubtedly sufficient importance to suggest the propriety of dividing the Tænioglossate Ctenobranchiata into two groups, founded upon it.

The only family of Ctenobranchiates in which the absence of a male organ has previously been known to occur, is that of the Vermetidæ, which have been recently made the subject of an anatomical investigation by Lucaze-Duthiers. As these are sessile animals, each individual being glued to its place upon some foreign body, and therefore unable to seek out a mate, an intromittent organ would be entirely useless to the male. Cuvier, reasoning *à priori*, deduced from this fact of their sessile habits the view entertained by him, namely, that they must have the power of self-impregnation; and he consequently separated them from the Ctenobranchiata as a distinct order, under the name of Tubulibranchiata. But the circumstance of sessile life is in reality not inconsistent with separation of the sexes. There is no difficulty in conceiving that the impregnation may take place in the way which is known to occur in the Lamellibranchiata, the spermatic particles reaching the ovary of the female through the medium of the water, into which they are discharged by the male. In our freely-moving Melanians, however, such a mode of impregnation is quite unnecessary; it is far more probable

[13] Verg. Anat. der wirbellosen Thiere, 1848.

that some direct connection takes place between the sexes; and it is highly desirable that this subject should be carefully investigated, at the proper season, by those who have opportunity of doing so.

These two groups, the (American) Melaniæ[14] and the Vermeti, the characters of which are now known, evidently constitute a distinct tribe of Ctenobranchiates, for which I would propose the name *Anandria*. Their lingual dentition is of the same type (3, 1, 3), though differing considerably in details. And it is not improbable that the Turritellidæ and some of the Cerithia must be referred to the same tribe, although I confess that the suggestion is based upon the examination of a limited number of individuals preserved in spirits. My opinion with regard to the Turritellidæ is strengthened by the remark of Forbes and Hanley in their description of this family,[15] that "the sexes are probably united;" an idea perhaps founded upon the absence of a copulatory organ in the male. And in Kiener's figure of the soft parts of *Turritella duplicata* Lam.,[16] there is represented a sinus in the side of the body and foot somewhat like that of the female Melanian.

I regret that I have nothing further to offer upon a subject of so much interest, and that materials are not now at hand for pursuing its investigation. Before closing, however, it will be proper to pass in review what has already been written upon the soft parts of our American Melanians, in order to substantiate the statements in the quotation and remarks at the head of this paper, which some may be inclined to regard as somewhat sweeping.

The first published description which I have been able to find of any species of the group under consideration, is by Professor Haldeman, the well-known author of the beautiful work on our fresh-water univalve mollusca, entitled, "A Monograph of the Limniades." In a paper "On the Melanians of Lamarck,"[17] he describes the *Melania virginica* of Say, as follows: "Animal with a truncated proboscidiform head, bearing two annulated tentacles, upon an enlargement of the outside basal portion of which the eyes are situated, but never beyond the middle of the tentacle; the mouth is provided with a double row of file-like teeth on each side; the foot is oval, not extending beyond the muzzle, slightly thickened, and of medium size; edge of the mantle continuous and simple. The exposed parts are colored with blackish upon a yellowish ground, which run transversely

[14] I have every reason to believe that the Old-World Melanians are also characterized by the absence of copulatory organs, but will not include them in the same group with the American species, until the fact is established by the study of the living animals, or at least of well-preserved alcoholic specimens.

[15] British Mollusca, vol. iii, p. 171.

[16] Kiener's "Iconographie des Coquilles vivantes;" *Turritelle*, pl. I.

[17] American Journal of Arts and Sciences, xli, (1841), 22.

across the rostrum and tentacles. Oviparous." The main fact of importance here brought out is that the animal is oviparous; the statement that the eyes are never beyond the middle of the tentacle would have been better left out, as it might lead to the supposition that they were sometimes placed near or at the middle, which is never the case; the mistake with regard to the lingual teeth is quite natural, as the armature of the tongue was little understood at that time; and the other characters mentioned (except the colors) are common to a large number of Rostrifers, but the description is satisfactory as far as it goes. In his subsequent remarks in the same paper, Prof. H. considers *Anculosa* to be intermediate between *Melania* and *Melanopsis*, and to be distinct from *Melania virginica* in the small size and discoidal shape of its foot. But, though the foot may assume this shape when contracted in the act of adhering to a rock in a strong current, it is not dissimilar to that of *M. virginica* in its normal shape, though undoubtedly somewhat shorter. On the other hand, the approximation of *Anculosa* to *Melanopsis* is erroneous, as the typical fresh-water forms of the latter group appear to have the foot prolonged anteriorly beyond the tip of the rostrum,—a character never seen in the true Melanians. The Melanopsis-group seems to be but little understood; some of the forms referred to it (the *Clionellæ*),[18] as I have recently discovered, are marine, and closely allied to the Pleurotomidæ, particularly to *Clavatula*.

The next notice on the structure of these animals occurs in Professor Baird's translation of the "Iconographic Encyclopedia," (New York, 1851), article Mollusca, vol. ii, p. 82, from the pen of Prof. Haldeman. In this work the Melaniidæ constitute the first family of the Ctenobranchiata, which is thus characterized: "The mantle is simple, without fringe or siphon; the head ends in a short trunk, and the food is vegetable, chiefly decaying Algæ." The family is made to include *Melania*, *Littorina*, *Planaxis*, *Eulima*, *Paludina*, *Amnicola*, *Valvata*, *Ampullaria*, *Leptoxis*, *Melanopsis*, *Io*, and (doubtfully) *Scalaria*;[19] thus uniting Lamarck's Mélaniens and Péristomiens, and adding a few genera from various other families. The rather comprehensive character of this "family," as understood by Prof. Haldeman, seems to depend upon the entirely unwarrantable dependence placed upon the ornamentation of the mantle edge, as a character of importance for purposes of classification. But it must here be remarked that this character, upon which Prof. H. so strongly insists in all of his papers, is one of very slight importance, as

[18] The lingual dentition in the type of *Clionella* (*C. buccinoides* = *Buccinum sinuatum* Born, dredged by me at the Cape of Good Hope) is of a very peculiar type, in some degree intermediate between that of Toxoglossa and Hamiglossa.

[19] "The mantle of Scalaria not having been described, its place remains doubtful." Hald., l. c., p. 83.

every one knows who has examined any considerable number of molluscous forms, both in gasteropods and acephals. There are even species in which the margin of the branchial siphon (perhaps the most important part of the mantle-edge) is beset with complicated fringes in some individuals, and nearly or quite simple in others, while every gradation between these two extremes may be found by the study of a sufficiently large number of specimens. "Fam. 2d, Cerithiidæ," of the work under consideration, is said to have "the general character of Melania, except that the mantle is scolloped." There are, however, plenty of Cerithia in which the mantle is simple-edged, and these animals have much more intimate relations to Melania than have most of the genera included in "Fam. 1, Melaniidæ."

Dr. Lea, in the ninth volume of his "Observations on the genus Unio," etc., and in minor papers published previously, recognizing the importance of subdividing the numerically enormous collection of forms commonly included under the "genus Melania," has very properly proposed distinct generic names for the several groups of species which are indicated by the conchological characters. Whether these characters are truly the most important that can be discovered, we do not pretend to decide; but there is no doubt that distinct types exist, around which the species may be grouped, in accordance with their affinities. That these genera run into each other, is no argument against the necessity of their acceptance, for the same may be said of very many genera in all classes of the animal kingdom, especially when we study the remains of their representatives in geological times. Dr. Lea, has, however, erroneously included the genus *Amnicola* in his family Melaniidæ.[20] That genus belongs to an entirely different group, nearly allied to the Rissoidæ, (if not, indeed, belonging to that family); the intromittent organ in the male being distinctly exserted.

The next-published observations upon the soft parts of American Melanians are those of Dr. Lewis,[21] who describes *M. subularis* Lea, and *M. exilis* Hald. The descriptions are confined to the colors and other characters to be observed in that part of the animal which is protruded from the shell in progression. It is interesting to notice that Dr. L. has observed the sinus in the side of the body of the female, although he has entirely misinterpreted its nature, and considered it a specific character. Thus he distinguishes the two species by "the presence of a sinus or fold in the sides of the foot and neck of *M. subularis*, and its absence in *M. exilis*." It is, therefore, evident that Dr. L. had before him the female of the former species and the male of the latter.

[20] Observations on the genus Unio, etc., vol. ix, (1862), p. 40.

[21] Proceedings of the Philadelphia Acad. Nat. Sci. for 1862, p. 588.

At a meeting of the Academy of Natural Sciences of Philadelphia, in February, 1863,[22] Dr. Lea "read part of a letter from Dr. Lewis, of Mohawk, New York, in which he said that he was gratified with one thing, which was not apparent to him at first. In his notes on *Melania subularis* Lea, and *M. exilis* Hald., two species of his neighborhood, he finds an evident confirmation of Mr. Lea's views about *Trypanostoma* and *Goniobasis*, to which two sections of Melaniidæ the two species belong. The soft parts affirm the correctness of Mr. Lea's generalizations from the shells. Dr. Lewis thinks the *sinus* in the sides of *subularis* is peculiar, and will be found in the whole group of *Trypanostoma* and the *granular sides* of *exilis* in the whole group of *Goniobasis*." We have here a proposition to consider the lateral sinus, which is now demonstrated to be a sexual difference, as a *generic* character. This simply shows how necessary it is to become acquainted with the general structure of the animals we investigate, before studying their generic and specific relations.

In connection with the subject of the relations of this *sinus*, it may be remarked incidentally that Dr. Lewis, in a paper published in 1861,[23] gives a description of the so-called *Amnicola lapidaria* (*Pomatiopsis*), stating that the soft parts in this species are "identical in form with *Melania*;" and in the paper in the Proceedings of the Academy of Natural Sciences of Philadelphia above cited, he gives a detailed account of his reasons for referring the species to the neighborhood of *Melania*, basing them chiefly upon the similarity in the movements of the animal, and in "the expansions and contractions of the foot in progressing." Dr. L. was here probably misled by the resemblance of certain sinuses in the sides of the foot of *Pomatiopsis lapidaria*, to that seen in the females of the Melanians. But the sinuses in the *Pomatiopsis* are of an entirely different character, having no relation to the sexual system, and being the result of a peculiar arrangement of the muscles, by which the "looping" method of progression on dry land, characteristic of that animal, is effected; and they occur on both sides of the body, and exist, of course, in both sexes.

We now come to the paper of Mr. Theodore Gill, published in the Proceedings of the Philadelphia Academy of Natural Sciences for 1863. This writer (l. c., p. 34) alludes only incidentally to the Melanians, following his predecessors in considering them to form a distinct family, which he has, however, restricted in a far more natural manner than had been previously done, as he excludes several incongruous forms formerly referred to it. He has also for the first time separated the American from the Old-World Melanians; saying, "The American Melaniidæ form a peculiar sub-family, Ceriphasiinæ," and (note under

[22] Proc. P. A. N. S., 1863, p. 26.

[23] Proceedings of the Boston Soc. Nat. Hist., viii, 255.

Amnicolidæ) "The American Melaniidæ, so far as I know, have not a fringed mantle, and consequently belong to a different group."

Finally, we have the recent paper of Professor Haldeman, "On Strepomatidæ as a name for a family of fluviatile Mollusca usually confounded with Melania."[24] Prof. H. here says that he had formerly "proposed, in accordance with the position assigned by Lamarck to his family Mélaniens, to restrict the name *Melania* to the American group," and that "it must not be forgotten that Lamarck's family of Mélaniens includes the three genera, *Melania*, *Melanopsis*, and *Pirena;* and that from its position in his system, and the structure of the European *Melanopsides* [opides], he would not have included the species (like the oriental *Melania amarula*, or the African *Pirena aurita*,) with a festooned mantle, which have gradually become the representatives of 'Melania' from the accidental circumstance that the Mollusc was first described from them. The fact that Lamarck commences his series with the large oriental species, is of little value, as he commences the genus *Planorbis* with *cornuarietis*, a discoid *Ampullaria*." But I have searched in vain through Prof. Haldeman's previous papers for a proposition to separate the American from the old world Melanians, and I must confess myself entirely at a loss to understand his allusion to Lamarck's views. That author says nothing about the character of the mantle-margin, either in his "*Système*," or in his "*Animaux sans Vertèbres;*" nor does he base his classification, either in the higher or the lower divisions, upon such a character, which could not therefore have affected his assignment of the family to a position, even if it had been known to him. The preceding family in the "*Animaux sans Vertèbres*," and some of the succeeding families, have sometimes a fringed mantle and sometimes a simple one. And Lamarck does not commence his *series* with the large oriental species, but with two American species.[25] Also, Lamarck's reference of *cornuarietis* to *Planorbis* has no bearing upon this subject, since the genus was not founded by him, but was used long previous for the true air-breathing Planorbes by O. F. Muller and other binomial writers.

Another quotation from Prof. Haldeman's paper: "Europeans are averse to giving up the name[26] for the oriental group; and as it is a matter of little scientific importance, if the *families* are properly recognized, I now reluctantly yield it to the oriental form, and consequently withdraw the American species from it."[27] With regard to this point, it may be remarked that the restriction of the name to the old-world species is a matter not of

[24] Proceedings of the Acad. Nat. Sci. of Philadelphia, 1863, p. 273.
[25] *M. asperata* and *M. truncata*. See An. sans Vert., vi, (1822), 164.
[26] Melania.
[27] Proc. A. N. S. Phil., 1863, p. 273.

opinion, but of necessity; since the type of *Melania* Lamarc, and indeed the only species mentioned by that author when he established the genus,[28] is the *Helix amarula* of Linnæus, an old-world Melanian.

I trust that it is unnecessary to reiterate here that the character of the margin of the mantle, whether fimbriated or not fimbriated, though made a family or a sub-family character by Haldeman and Gill, respectively, is of the slightest possible importance in comparison with others easily discoverable upon patient observation. That the old-world Melanians are distinct as a sub-family from the American forms, I do not deny. But the truly important distinction consists in this: the old-world species are ovo-viviparous, like *Paludina* (*Viviparus*), while the American species are oviparous. Woodward,[29] H. and A. Adams,[30] and Carpenter,[31] all state that the species of the Melaniidæ are "sometimes viviparous," but do not attempt to establish a distinction on this account between the American and the old-world species, nor do they inform us in what geographical area their viviparity has been observed. I am inclined to consider the old-world group as ovo-viviparous, from having found it to be the case in all of the species of that group accessible to me,[32] while all observations which have been made upon the American species lead to prove them to be oviparous.

Prof. Haldeman, in referring to the paper of Mr. Gill (above quoted), remarks that Mr. G. "there includes the Melaniidæ in his 'Synopsis of the families of Pectinibranchiates represented in the fresh-water streams of North America,' although he admits (note under Amnicolidæ) that they 'have *not* a fringed mantle, and consequently belong to a *different* group' from the 'true Melanians.' How, then, can they be Melaniidæ? Of this group he forms 'a peculiar *sub*-family, *Ceraphasiinæ*.' From his heterogeneous Melaniidæ he rejects certain forms, including *Melanopsis* and *Pirena*, (probably *P. atra* (Linn.) and *P. fluminea* (Gmel.,)) to form a family Melanopidæ (and also a sub-family Melanopinæ), to which his Cera (Ceri-?) phasiinæ should belong, as Melanopsis seems to have a simple mantle."[33] But it is plain that Mr. Gill, in saying that the American Melanians belong to a different *group* from the old-world species, did not mean that they belong

[28] Mém. de la Soc. d'Hist. Nat. de Paris, Prairial an vii (1799), p. 75, and Systéme des Animaux sans vertèbres, (1801), p. 91.

[29] Manual of the Mollusca, p. 130.

[30] Genera of Recent Mollusca, i, 294.

[31] Smithsonian Report for 1860, p. 206.

[32] I have not had opportunities of examining any of the animals of this group preserved in spirits, but have found no difficulty in making out the fact of ovo-viviparity by macerating the dried animal in cabinet specimens of the shells, when the oviduct in the females, in several species, was found to be filled with young animals with four- to six-whorled shells about one eighth of an inch in length.

[33] *Loc. supra cit.*, p. 274.

to a different family, as he distinctly states that they constitute a sub-family only; and he was quite right in considering the fringing of the mantle as not of sufficient importance to form a family difference. Indeed, it is doubtful whether this could be considered as of sub-family importance, were it not coördinate with the far more important character of ovo-viviparity alluded to above. The family Melaniidæ of Mr. Gill is far from being "heterogeneous;" it was indeed so well restricted, even upon the meagre data then at hand, that subsequent investigations do not make it necessary to alter its limits. Whether Mr. Gill's family "Melanopidæ" is sufficiently distinct in "the projecting foot of the animal and the notch in the aperture of its shell,"[34] remains to be determined by future investigation. But, in any case, it would be quite unscientific to approximate this group to the American Melanians, on account of their simple pallial margin.

[*Note.*—While the above article is in press, I have an opportunity, through the kindness of Mr. Binney, to examine the soft parts of a single specimen of the *Io fusiformis*, preserved in spirits. Here I find the glandular laminæ of the generative duct to be arranged nearly as in *Melania virginica* (p. 43). The left or inner lamina is distended with the generative products, while the outer one is folded over it like a sheath.]

ART. VI.—*The original accounts of the displays in former times of the November Star-Shower; together with a determination of the length of its cycle, its annual period, and the probable orbit of the group of bodies around the sun;* by H. A. NEWTON.

[Concluded from vol. xxxvii, p. 389.]

IN the last volume of this Journal (pp. 377–389) were given the accounts of displays of the November star-shower on thirteen different years, from A. D. 902, to A. D. 1833. From them may be obtained some important conclusions.

1. *The length of the annual period.*—The middle of the first display may be considered as Oct. 13th, A. D. 902, at 5 o'clock, A. M., Italian time. The same hour, New Haven time, may be taken for the middle of the last shower, Nov. 13th, A. D. 1833, or in old style, Nov. 1st. Between these two dates were 931 years, of which (in old style) 233 were leap years. There are 19 odd days, and six hours are to be added for the difference of longitude. This interval contains 931 periods. Hence, one period is $365 + (233 + 19{\cdot}25) \div 931$, or 365·271 days.

2. *The length of the cycle.*—A glance at the dates shows that there is a cycle of about one-third of a century, and that during a period of two or three years at the end of each cycle we may

[34] Gill, *loc. cit.*, p. 34. The *Clionellæ*, as stated in a previous paragraph of this paper, should be rejected from this group, being marine species allied to *Pleurotoma*.

expect a shower. The two showers in A. D. 1832, and 1833, indicate that the latter was toward the close of this short period. In like manner, the two showers in A. D. 902 and 934, being only 32 years apart, belong evidently, the former toward the close of the period, and the latter toward its beginning. The two years A. D. 902, and A. D. 1833, occupy then, approximately, corresponding places in the cycle. The interval, divided by 28, gives 33·25 years for the length of one cycle.

3. Various facts respecting these showers are shown by the following table. The first column contains the number of the display as given in the earlier part of this article, the second the year, and the third the day and hour of what I consider the historic date of the shower. The hour is somewhat arbitrary. I have assumed that the maxima of the displays recorded in the European annals were 5 o'clock, A. M., Paris time, or 17 hours from the preceding noon. This of course may involve an error of some hours, which is to be borne in mind in considering the remainders in another column. For the showers taken from the Chinese records, seven hours are subtracted from the seventeen to allow for the difference of longitude; and for the two American showers, four and five hours are added. No. 8 was observed both in Europe and China, and No. 6 at Baghdad. Hence, three hours are taken from each date. The shower of 1832 was mainly east of Paris, and one hour is therefore subtracted.

In the fourth column is the earth's longitude at each date, computed by Le Verrier's tables (*Annales de l'Observatoire*, iv, 102–206). These longitudes are approximately represented by the formula $a - nt$, where a is $51^\circ\,17'{\cdot}7$, n is $1'{\cdot}711$, and t is the number of years from the time of the shower to Jan. 1st, A. D. 1850. These values of $a - nt$ are given in the fifth column. Subtracting them from the corresponding longitudes in the fourth column, gives the remainders in the sixth column.

We may suppose a cycle to begin midway between the displays of November, 1832, and November, 1833. If the beginning of a year be reckoned from the day of the shower, the beginning of the cycle may be written 1832·50. Subtracting now from this date multiples of 33·25 years, we have the numbers in the seventh column for the dates of the beginning of the cycles. Subtracting now these from the years given in the second column, and we have the remainders in the eighth column. Each remainder represents evidently the number of years from the beginning of the cycle to the time of the shower.

The last column contains the sum of the perturbations of the earth's distance from the sun, caused by the moon and planets, computed by the tables of Le Verrier. The unit is the seventh decimal of the sun's mean distance, and represents about 9·5 miles.

TABLE.

No.	A.D.	Day and hour.	Longitude.	$a - nt$.	Diff.	End of cyc.	Diff.	Perturb.
		d h	° ′	° ′	′			
1	902	Oct. 12 17	24 16·6	24 18·1	− 1·5	901·50	+ ·50	−238
2	931	14 10	25 57·5	25 7·7	+49·8	934·75	−3·75	+497
3	934	13 17	25 31·6	25 12·8	+18·8	934·75	− ·75	+467
4	1002	14 10	26 44·8	27 9·2	−24·4	1001·25	+ ·75	+366
5	1101	16 17	30 2·4	29 58·6	+ 3·8	1101·00	0	+126
6	1202	18 14	32 25·5	32 51·4	−25·9	1200·75	+1·25	+622
7	1366	22 17	37 47·9	37 32·0	+15·9	1367·00	−1·00	−621
8	1533	24 14	41 11·7	42 17·8	−66·1	1533·25	− ·25	− 48
9	1602	27 10	44 18·9	44 15·9	+ 3·0	1599·75	+2·25	−381
10	1698	Nov. 8 17	47 20·6	47 0·1	+20·5	1699·50	−1·50	−269
11	1799	11 21	50 1·6	49 52·9	+ 8·7	1799·25	− ·25	−146
12	1832	12 16	50 49·0	50 49·4	− 0·4	1832·50	− ·50	+ 37
13	1833	12 22	50 49·5	50 51·1	− 1·6	1832·50	+ ·50	+316

4. *The mean motion along the ecliptic of the node of the orbit of the group.*—The mean longitudes of the node are approximately represented by the numbers in the fifth column. Hence, the coefficient 1′·711, by which these numbers were obtained, represents the annual procession of the node along the ecliptic, longitude being reckoned from the mean equinox. The remainders in the sixth column represent the distances of the earth from the mean positions of the node at the times represented in the second and third columns. These may be changed into time by allowing 2′·5 for each hour. Errors of the assumed historic dates are of course included in these remainders.

5. *The length of the part of a cycle during which showers may be expected.*—The remainders in the eighth column of the table show that the display in A. D. 1366 was one year before the beginning of the cycle, as above determined, while that of A. D. 1202 was a year and a quarter after it. Both were extraordinary showers. Hence the length of that part of the cycle during which extraordinary displays may occur, is at least 2·25 years. The minor displays, Nos. 2, 9, and 10, indicate that unusual numbers of shooting stars, sufficient to attract attention, may be seen through a period of five or six years, at least.

6. *Does a ring around the sun, of* UNIFORM *density through its circuit, properly represent the shape of the group?*—I think not. It is not absurd to suppose that the earth passes very near to a ring of bodies, and that by the action of the planets and moon on the earth and the ring, we are sometimes thrown into it, and sometimes pass by without meeting it. Let us see whether this is probable.

If the planetary and lunar perturbations of the earth's radius vector were at the time of the showers always very large, and of the same sign, it would suggest the existence of a ring passing at the node, just outside, or just inside, of the earth's orbit. But

the last column of the table shows no regularity. On the contrary, while the sum of the maxima of all the plus perturbations of the radius vector is 884, and that of the minus perturbations is 958, we have two remarkable showers occurring, one in A. D. 1202, when the increase was 622, and one in A. D. 1366, when the decrease was 621. If then a uniform ring, crossing the ecliptic just inside or just outside of the earth's orbit, be supposed, the cause of the periodicity cannot be the perturbations of the earth's radius vector. The greatest possible perturbation in either direction being only about 9000 miles, it is highly improbable that the earth passes sometimes inside and sometimes outside of a thin ring.

We might however suppose that the ring sways back and forth, and thus produces the periodicity. The mean motion of the bodies of the ring and its eccentricity are unknown, and hence we cannot speak positively of its irregularities. But it is probable that its radius vector would not suffer larger perturbations than that of the earth. The lunar action is wanting, while the earth ought to work the same effect each year. The motion is retrograde, as will be shown, hence the action of the planets ought to be less. On the other hand, there is needed a very large action, sufficient to entirely mask the irregular perturbations of the earth's radius vector.

A revolution of the apse of the ring in 33·25, or even in 66·5 years, could explain the periodicity, but this motion would be enormously greater than those usual in the planetary system. *The supposition of a ring of uniform density through its circuit seems then very improbable.*

7. The appearance of meteors in rather more than usual numbers on the 13th and 14th of November of other years of the cycle than the two or three near its beginning, suggests however a ring of some kind as the true form of the group. The probability of this shape is strengthened by the analogy of the August meteors, whose regular recurrence seems to imply that that group is a ring.

We may indeed suppose a globular group, whose mean motion is exactly that of the earth, and that perturbations in longitude produce the periodicity. But what planets, acting on a body whose periodic time is exactly one year, can cause a large equation of longitude, having a period of 33·25 years?

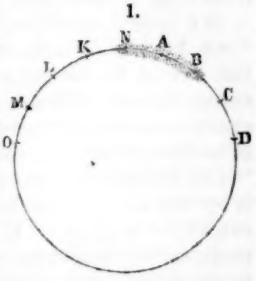
8. If the group is a ring, it has then, in all probability, very unequal density through its circuit. We pierce through it every year, and each time in a new place. It is only in those parts of the ring that are at the node with us near the end of the cycle, that we meet with very large numbers of shooting stars. The most natural supposition is that there is a small section of the ring where the bodies are numerous, a few stragglers being scat-

tered along the rest of its circuit. In short, we are to conceive the group as a cloud of small bodies, extending along the arc of an ellipse whose focus is the sun, that arc being the base of a sector equal to one-tenth, or one-fifteenth, of the ellipse. In this limited portion, however, there may be great inequalities, or even discontinuity.

9. If the motion of a body in an orbit inclined a few degrees to the ecliptic is retrograde, the longitude will evidently increase with the time. If the motion is direct, the longitude of the nodes will decrease as time increases. *The motion of the group of bodies to which the November meteors belong, is therefore retrograde.*

10. Let NABC represent the orbit of the group, cutting the ecliptic in N. Let the earth pass through the middle of the group on a certain year. One year later, the centre of the group will not be at N, but at some other point, as A, or K, having perhaps meanwhile described one or two revolutions. On following years, the centre of the group will be at B, C, D, &c., or at L, M, &c., the distances NA, AB, BC, &c., being arcs of the orbit described in equal times. The length of the group must be at least two and one-fourth times the distance NA, since a shower may occur during a period of at least two and one-fourth years.

1.



Now it is evident that NA is $\frac{1}{33 \cdot 25}$th part of the whole orbit. For, after a complete cycle, the group must be near N when the earth is there; and the series of points A, B, C, &c., cannot go more than once around the orbit in one cycle without causing more than one period in each 33·25 years.

11. The number of complete revolutions in a year cannot exceed two. For an orbit whose periodic time is $\frac{1}{8}$ has a major axis $2(\frac{1}{8})^{\frac{2}{3}}$, which is less than unity, or less than the distance from the sun to the earth. In one year, then, the group must describe either $2 \pm \frac{1}{33 \cdot 25}$, or $1 \pm \frac{1}{33 \cdot 25}$, or $\frac{1}{33 \cdot 25}$ revolutions.

12. These five velocities are not all equally probable. Some of the members of the group that visited us last November gave us the means of locating approximately the central point of the region from which the paths diverge. Mr. G. A. Nolen has, by graphical processes specially devised for the purpose, found its longitude to be 142°, and its latitude 8° 30′. This longitude is very nearly that of the point in the ecliptic toward which the earth is moving. Hence, the point from which the absolute motion of the bodies is directed (being in a great circle through the other two points), has the same longitude. The ab-

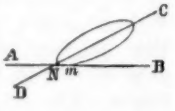
solute motion of each meteor, then, is directed very nearly at right angles to a line from it to the sun, the deviation being probably not more than two or three degrees.

Now if in one year the group makes $2 \pm \frac{1}{33}, \frac{1}{25}$ revolutions, there is only a small portion of the orbit near the aphelion which fulfils the above condition. In like manner, if the periodic time is 33·25 years, only a small portion of the orbit near the perihelion fulfils it. On the other hand, if the annual motion is $1 \pm \frac{1}{33}, \frac{1}{25}$ revolutions, the required condition is answered through a large part of the orbit. Inasmuch as no reason appears why the earth should meet a group near its apsides rather than elsewhere, we must regard it as more probable that the group makes in one year either $1 + \frac{1}{33}, \frac{1}{25}$, or $1 - \frac{1}{33}, \frac{1}{25}$ revolutions.

13. If either of these two mean motions are correct, the absolute velocity of the meteors will be very nearly equal to that of the earth. Hence, the inclination of the ring to the ecliptic will be about twice the latitude of the radiant, or 17°, the motion being, as before shown (9), retrograde.

14. Let AB be the earth's path near the node N of the orbit of the group, and let CD be the orbit of the group. Let the directions of the motions be from A to B, and from C to D. It is reasonable to suppose that the shape of a section of the group made by a plane tangent to the two orbits, will be an oval. Also, a curve in that section representing parts of the group of equal density, will be an oval. If now the group has not arrived at N when the earth is there, the maximum display of meteors is to be expected later in the year, that is, when the earth is at *m*. On the contrary, if the group has passed the node before the earth reaches it, the maximum display is to be expected earlier in the year.

2.



Now if the group makes $1 + \frac{1}{33}, \frac{1}{25}$ revolutions in a year, its positions on successive years will pass from C toward D. Hence, in that case, in the earlier part of the two or three years during which a shower is to be expected, the display would be later in the year than usual, and conversely.

On the other hand, if the group describes $1 - \frac{1}{33}, \frac{1}{25}$ revolutions in a year, its position on successive years will pass from D to C, and hence in the earlier part of the two or three years the display is to be expected earlier than usual, and conversely.

By the former of these two suppositions, we ought evidently to have the sign of each remainder in the sixth column unlike that of the corresponding remainder in the eighth column. By the second supposition the signs should be alike. It ought rather to be said that there is a tendency to produce these effects, for the sixth column contains unavoidable errors resulting from the inexact historic dates. An examination of the two columns

shows a decided tendency toward opposition of sign of the remainders, and hence the first must be considered as the more probable velocity. This opposition of signs and its significance was pointed out to me by Mr. J. W. Gibbs, to whom I am indebted for other valuable suggestions.

15. If the annual motion of the group is $1 + \frac{1}{33}\cdot\frac{1}{33}$ revolutions, we may determine the orbit. Between the shower of A. D. 902, and that of A. D. 1833, were $365 \times 931 + 233 + 19{\cdot}25$, that is, 340067·25 days. During this time the group has made $931 + 28$ revolutions, excepting a small fraction of one revolution to be determined from the procession. The procession is 26° 33′, of which 12° 58′ is due to the precession of the equinoxes. The remainder is to be reduced to the plane of the orbit, and regarded as described with a radius vector greater than the mean distance. Hence it may be called $\frac{1}{33}$th of a revolution. The time of a sidereal revolution of the group around the sun is, then, 340067·25 ÷ 958·96, or 354·621 days.

16. The accuracy of this periodic time is worthy of notice. The principal uncertainty arises from the assumption (2) that the shower of A. D. 902 occupies the same place in the cycle as that of A. D. 1833; in other words, that the earth passes through the same part of the group in those two years. An examination of the remainders in the eighth column of the table leads me to believe that the probable error of this supposition would be less than one year. Now if this error was one year, plus or minus, the periodic time would be $\frac{340067{\cdot}25 \pm 365{\cdot}271}{958{\cdot}96 \pm 1}$, or $354{\cdot}621 \pm \dot{0}11$ days. This error of the periodic time would be only about 16 minutes. There is a similar accuracy in each of the other possible periodic times.

The cause of this accuracy is evident. The periodic times of the group and of the earth are like the two divisions of an immense vernier, extending back nearly a thousand years, and we measure from the twenty-ninth coincidence.

17. Each body of the group must have its own elliptic orbit about the sun, this orbit being, of course, slightly modified by the action of the rest of the group. *The major axes of all these ellipses are equal.* For otherwise the bodies would soon scatter themselves along the whole circuit of the ring, and there would be a display every year. A very slight deviation from a common velocity might be corrected by the attraction of the group.

18. *The elements of the mean of these orbits.*—The semi-major axis is evidently $\left\{\frac{354{\cdot}621}{365{\cdot}256}\right\}^{\frac{2}{3}}$, or 0·98049, the mean distance of the earth being unity. The earth's radius vector, at the time of a shower, represented below by r, is 0 98887. The velocities of the earth, and of any member of the group, are represented

(Laplace, *Méc. Cél.*, i, 190) by the formula $\left(\frac{2}{r}-\frac{1}{a}\right)^{\frac{1}{2}}$, where a is the semi-major axis. These are, respectively, 1·0112 and 1·0013, the earth's mean velocity being unity. The eccentricity of an orbit is obtained by the formula (*Méc. Cél.*, p. 191),

$$a(1-e^2)=r^2\sin^2\varepsilon\left\{\frac{2}{r}-\frac{1}{a}\right\},$$

where e is the eccentricity, and ε is the angle which the motion of the meteor makes with a line from it to the sun. Reducing, we have $e^2=\cos^2\varepsilon+\left(\frac{r-a}{a}\right)^2\sin^2\varepsilon$.

The value of ε is not well known, but its mean value does not probably (12) differ more than two or three degrees from a right angle. We may then consider $\sin\varepsilon$ as unity. The fraction $\frac{r-a}{a}$ is ·00853. Hence, if we take the base of a triangle equal to ·00853, and the perpendicular equal to $\cos\varepsilon$, the hypotenuse will be equal to the mean value of the eccentricity. The ring is then nearly circular. Its inclination is, as before stated, about 17°; that is, twice the latitude of the radiant.

19. The velocity with which these bodies enter the atmosphere, is easily computed. Allowing for the earth's attraction, it is about 20·17 English miles per second, or 32·44 kilometers, considering the earth's mean distance 95,000,000 miles.

20. The length of the group, as it is at least one-fifteenth of the length of the orbit, must be more than 40,000,000 of miles. If a shower lasts five hours, the thickness of the ring would be the distance passed over by the earth in that time multiplied by the sine of the inclination of the orbit, or more than 100,000 miles.

21. Since the periodic time is limited to five possible values, each capable of an accurate determination, and since therefore from the position of the radiant the inclination of the orbit can be found, it seems possible to compute the secular motion of the node for each periodic time with considerable accuracy. Since now the actual motion of the node is known, we have thus an apparently simple method of deciding which of the five periods is the correct one.

22. It may be well to indicate those parts of the earth in which we have most reason to look for unusual numbers of meteors in coming years. The annual period being 365·271 days, the excess over even days is 0·271. This multiplied by 31 gives 8·401 days. The excess over eight days corresponds to about 144° of longitude. If, then, a shower occurs in A. D. 1864 (31 years after 1833), it seems most reasonable to look for its greatest display (on the morning of Nov. 14th) 144° west of our At-

lantic States, that is, in the western part of the Pacific Ocean and in Australia. In 1865, it may be looked for as central 97° farther west, or in western Asia and eastern Europe; and in 1866, on the western Atlantic.

The year in which we have most reason to expect a shower, is 1866, since the cycle of 33·25 years is probably to be reckoned from some date between November in 1832, and in 1833.

These places and times are named with hesitation—rather to guide observation, than as predictions. The causes alluded to above (14), and the possible perturbations and irregularities of structure of the group, may cause unexpected variations of time and place.

ART. VII.—*On Molecular Physics;* by Prof. W. A. NORTON.

IT is proposed, in the present paper, to give a general exposition of a Physical Theory of Molecular phenomena, based upon the highest generalizations, and the most reliable physical conceptions to which the progress of science has hitherto conducted.[1] A theory, so comprehensive in its scope, can be completely substantiated only by undertaking a thorough discussion of the minute details of special phenomena in the several departments of physical science, and subjecting it at all practicable points to the rigid test of numerical calculation. But before any detailed discussions can be entered upon, we must deduce from the fundamental conceptions adopted the general principles of molecular action, or the laws of the molecular forces, note the characteristic features of the different provinces into which the entire field of research is naturally divided, and trace out the general relations which they bear to each other, or, in other words, recognize the mutual dependence and essential correlation of special physical forces.

The established truths and generally received ideas, which form the basis of the theory, are as follows:

1. All the phenomena of material nature result from the action of force upon matter.

2. All the forces in operation in nature are traceable to two primary forces, viz: attraction and repulsion.

3. All bodies of matter consist of separate indivisible parts, called atoms, each of which is conceived to be spherical in form.

4. Matter exists in three different forms, essentially different from each other. These are: (1) ordinary, or gross matter, of

[1] The principal features of the general theory here propounded, have, with few exceptions, been advocated by the author before the Connecticut Academy of Arts and Sciences, at various meetings of the Academy during the last six years.

which all bodies of matter directly detected by our senses either wholly, or chiefly consist. (2) A subtile fluid, or ether, associated with ordinary matter, by the intervention of which all electrical phenomena originate, or are produced. This *electric ether*, as it may be termed, is attracted by ordinary matter, while its individual atoms repel each other. (3) A still more subtile form of ether, which pervades all space and the insterstices between the atoms of bodies. This is the medium by which light is propagated, and is called the *luminiferous ether*, or the *universal ether*. The atoms, or "atomettes," of this ether mutually repel each other; and it is attracted by ordinary matter, and is consequently more dense in the interior of bodies than in free space.

5. Heat, in all its recognized actions upon matter, manifests itself as a force of repulsion.

The corner stone of a physical theory of molecular phenomena must consist in the conception that is formed of the essential constitution of a single molecule; understanding by a molecule an atom of ordinary matter indued with the properties and invested with the arrangements which enable it to exert forces of attraction and repulsion upon other molecules. In seeking for this, the most philosophical course that can be pursued is to follow out to their legitimate conclusions the general principles already laid down. We have admitted the existence of a subtile ether, attracted by all bodies, and pervading their interstices; now if bodies attract this ether, the atoms of which they are composed must exert an attractive action upon it. Every atom must, therefore, be surrounded with an *ethereal atmosphere*, condensed upon its surface, and extending indefinitely outward. Again, it is conceded that the electric ether, or fluid, if it exists, must be attracted by ordinary matter; but if this attraction subsists, it must be exerted by the individual atoms, and therefore every atom must also be surrounded with an atmosphere of electric ether—an *electric atmosphere*, as it may be termed. We must suppose that the interstices between the atoms of this electric atmosphere will be pervaded by the more subtile ethereal atmosphere. We are thus led to conceive of a molecule as consisting of an atom surrounded with two atmospheres, ethereal and electric—the former being the more attenuated, and pervading the other. We may suppose either that these two ethers exercise no direct action upon each other, or, what is more probable, that the electric atoms attract the ethereal, and are therefore surrounded, like the central atoms of the molecules, with ethereal atmospheres. To this supposed fact we may attribute the mutual repulsion subsisting between the electric atoms; and thus restrict the fundamental property of repulsion to the atoms of the universal ether.

The conception here formed of a molecule involves the idea

of the operation of the two forces of attraction and repulsion; a force of attraction is exerted by the atom upon each of the two atmospheres surrounding it, and a force of mutual repulsion between the atoms of each atmosphere. These we regard as the *primary forces* of nature, from which all known forces are derived. They determine, primarily, the physical relations of the atom to its atmospheres. In seeking for the molecular actions that may result from their operation, there are two different routes that may be taken. We may conceive that the atmospheres surrounding each atom are, naturally, in a condition of statical equilibrium, and that the primary forces with which the molecule is invested take effect at all distances, without the intervention of any medium, and unobstructedly through all intervening matter; or we may conceive the natural equilibrium of the molecular atmospheres to be a dynamical one, and that, as a necessary consequence, recurring impulses, both attractive and repulsive, are propagated outward by the surrounding ether, from each molecule, and take effect upon other molecules. Here, as before, we shall follow the indications of existing science, which, as will be generally conceded, point to a dynamical origin of the molecular forces. The ideas we have thus been led to form with regard to the real nature and mode of action of these forces, are as follows:

The *molecular forces* consist of—

1. A repulsive action of the electric atmosphere of a molecule exerted, primarily, upon the electric ether immediately exterior to it. This force of repulsion is made up of recurring impulses, which are propagated in waves through the circumambient electric ether. These impulses fall upon the electric atmospheres of contiguous molecules, are thence propagated down to the surfaces of the central atoms, and take effect upon these as a force of repulsion.

2. An attractive action exerted by the central atom of the molecule upon the electric ether surrounding it; originating a series of successive contractions of this atmosphere, and thus of inward acting impulses, which are propagated outward and form a set of attractive waves. These are received, like the repulsive impulses, upon the surfaces of contiguous electric atmospheres, and propagated to the central atoms, upon which they take effect as an attractive force. The recurring contractions of the atmosphere, here supposed, do not necessarily imply that the force which produces them acts by impulses, for every such contraction must develope a resistance, which will occasion a subsequent expansion; and, at the same time, recurring expansions should result from the similar impulses propagated from surrounding molecules. The electric atmospheres that envelop the atoms of bodies may accordingly be in a perpetual dynamical

condition of alternating contractions and expansions, or of alternating inward and outward movements of their atoms, although the primary forces acting upon these atoms should be continuous in their action.

But if we confine our attention to the action of a single atom upon its electric atmosphere, it will be seen that the expansions, which of necessity follow the contractions, must be of less extent than the contractions; for a part of the contractile force is expended in impelling a portion of the universal ether compressed upon the surface of the central atom normally outward from this surface. To the extent that this effect takes place will the contraction of the atmosphere exceed the expansion which immediately follows it, and an effective attractive force be propagated through the surrounding electric ether. We are thus led to recognize the existence of a third molecular force, viz: a force of repulsion originating in the attractive action exerted by the atom of the molecule upon its electric atmosphere.

3. A third molecular force, then, consists of a series of repulsive, or outward acting impulses, imparted to the universal ether at the surface of the atom of a molecule by the contractile force exerted by the atom upon its electric atmosphere. This repulsion is equal, at its origin, to the attraction which developes it. It is propagated in waves which, unlike the waves conveying the other molecular forces, proceed through the universal ether. These waves, if each contraction of the atmosphere were not followed by a partial expansion, would be of the character of "waves of translation," and would convey only outward acting impulses; they are, in fact, oscillatory waves, in which the outward predominate over the inward acting impulses.

The force thus originating may be regarded as the primary force of *heat*, and may be termed *heat-repulsion*. The other two molecular forces may be designated as the forces of *electric attraction* and *electric repulsion*. But they should not be confounded with the special electric forces that come into play whenever the natural quantity of electric ether associated with atoms, or present on different sides of atoms, experiences any material increase or diminution—which will be considered in another connection.

The molecular forces that have now been specified might be otherwise characterized as follows: (1.) A repulsion of the one electric atmosphere for the other, operating through the intervention of the electric ether posited between the two. (2.) An attraction of the gross atom of the one molecule for the electric atmosphere of the other, also taking effect by means of the intervening electric ether. (3.) A repulsion exerted by the atom of the one molecule upon that of the other, through the intervening universal ether, and originating in the attraction just

mentioned. These forces consist of recurring impulses propagated in waves through the ethereal media, which take effect ultimately as attractive, or repulsive, impulses, upon the central atoms of molecules. The law of diminution of the propagated forces is that of the inverse squares.

If the *ethereal*, as well as the electric, atmospheres of particles, be conceived to be in a state of dynamical equilibrium, their alternate contractions and expansions should originate oscillatory waves that would be propagated indefinitely onward through the ether of space. If we admit, with Professor Challis, that such purely oscillatory waves, when they fall upon particles, will give rise to an attraction, or a repulsion, according to the breadth of the waves, in comparison with the diameter of the particles, and that the force of gravitation may be conveyed by such waves, we have in the supposed dynamical condition of ethereal atmospheres of particles a possible origin of waves of gravitation, which cannot be found, primarily, in any supposed motion of gross atoms in an isolated condition. It should be observed, too, that the dynamical condition of atmospheres, here considered, is really a necessary consequence of the first operation of the force of attraction of atoms upon the surrounding ether, if the elasticity of the ether be perfect.

A different view of the possible nature and origin of the molecular forces from that which has been given, may be obtained by changing our stand point.

We may conceive the same three forces, viz: one of attraction, and two of repulsion, to be in operation, but we may replace the forces of electric attraction and repulsion by equivalent forces propagated through the universal ether. This may be realized as a physical conception by regarding the atoms of the molecules and those of the surrounding electric ether, each encompassed by its ethereal atmosphere, as being, or rather their atmospheres, in the dynamical condition of alternate contraction and expansion, and thus as being centres from which proceed oscillatory waves; and that as the result, in accordance with the general theory so ably advocated by Professor Challis, the electric atoms of two atmospheres may repel each other, and the central atoms which they surround may also repel each other; the general result being that similar atoms repel, and dissimilar attract. Upon this view the forces we have deduced from the dynamical state of the *electric* atmospheres, which must still be in operation, must be overshadowed by those now considered. Upon the former idea it is the forces now derived from the dynamical state of the *ethereal* atmospheres that must be overshadowed by the others. A discussion of phenomena can alone decide which of these two general views should be adopted. In the present memoir we shall chiefly occupy the ground first taken.

Among the physicists of the present day there seems to be a growing inclination to discard the notion of an electric fluid as distinct from the ether of space, and attempts have been made by Challis, Tyndall, and others, to frame a consistent dynamical theory of molecular forces and phenomena, based upon the supposed existence of only two forms of matter, viz: gross matter, and the ether of space. The fundamental position taken by these distinguished physicists is that the molecular forces, including heat, are conveyed by purely oscillatory waves, and originate in a vibratory motion of the ultimate particles of bodies. Against this idea, however plausible it may seem, and however admirable may be the ingenuity and skill with which it has been sustained, many serious objections may be urged. One or two of these may be briefly stated.

1. No possible mode of explaining the phenomena of electricity and magnetism has yet been indicated by the advocates of this theory. The electric fluid is expelled by them from the vast field it has hitherto occupied, but all attempts to supply its place have proved futile.

2. Another obvious objection is that vibratory motions of gross atoms are supposed to originate the forces by which such atoms are primarily aggregated into masses, whereas it is essential to the possibility of such vibrations that contiguous atoms should exercise a mutual action upon one another, that is, be previously aggregated. We must suppose, then, the existence originally of other forces, to bring isolated atoms together and make the supposed forces due to vibratory motions of the atoms, possible; that is, these latter forces become possible only when there is no longer any farther occasion for them. We have seen that another possible origin may be ascribed to such oscillatory waves that does not involve the physical impossibility just referred to, from which those who seek for the key to all molecular phenomena in the motions of gross atoms, can hardly escape.

3. The notion advocated by Tyndall in his admirable work on "Heat considered as a mode of Motion," that heat and light originate in a vibratory motion of ordinary atoms, involves the supposition that these atoms are capable of vibrating at the astonishing rate of six hundred trillion vibrations in a second, while the most rapid vibration of atoms, or of a collection of atoms, known to take place in the production of sound, does not exceed 24,000 per second. It may be conjectured that this immense chasm may be spanned by the idea that the ultimate particles of bodies are immeasurably smaller than any collection of atoms which may be simultaneously vibrating when bodies emit sound; and that since a musical string vibrates more rapidly in proportion as it is shorter, a single particle may vibrate at an inconceivably rapid rate by reason of its exceeding

minuteness. But the analogy here supposed does not exist, as a physical fact, and no such inference can be drawn from it; for the rate of vibration of the string depends upon the distance between its two fixed points, but in no proper sense can it be said that two particles between which another is situated, are fixed, so as to be incapable of taking on the motion imparted to the intermediate one. So far from this being the case, the displaced particle can only vibrate by reason of the reaction of the contiguous particles to the action which it exercises upon them; and in receiving this action the motion must be transmitted. If, to remove the difficulty, we conceive the particle to oscillate as if it were wholly isolated, in union with an oscillatory wave falling upon it, we then fall upon the second objection stated above, and seek in vain through the universe for the vibratory motion of atoms of ordinary matter in which this wave conveying such wonderfully rapid vibrations can have originated. We, at the same time, remove the necessary foundation for the explanation of a variety of special facts and phenomena, which require the assumption of special rates of vibration, proper to the particles of different bodies; as the different colors of bodies, &c.

Again, if the rates of vibration of ultimate particles depend upon the mutual actions subsisting between the displaced particle and those adjacent to it, the vibrations in which the heat-force is supposed to consist, should be propagated from particle to particle, just as any mechanical force is; in other words, heat should be conducted after the same manner, essentially, and at the same rate that sound is conducted by the same medium.

By ascending to the reservoir of primary force, from which all the different streams of force flow, as has been attempted in this communication, we may avoid some of the difficulties attending the rejection of the idea of the existence of an electric ether; and in many portions of the field of physical science the part played by the electric ether is so similar to that which we may suppose would be performed by the universal ether under similar circumstances, that the suspicion at times arises that all the offices now attributed to the former will eventually be found to be discharged by the latter. If so, the processes of operation will not of necessity be changed, but only the agent or medium.

Admitting that the molecular forces consist of two forces of repulsion and one of attraction, as characterized on p. 64, let us proceed to inquire into the variations that may occur in the effective action of two similar molecules, separated by various intervals of distance. Let x= the distance between two molecular atmospheres; r= the radius of either atmosphere; m= the constant of electric repulsion, that is, the force of electric repul-

sion exerted upon either atom, when $x=1$; and $n=$ the constant of the electric attraction, which will also be the constant of the equal force of repulsion propagated from the surface of the atom through the universal ether. Also let $u=$ the force of electric repulsion, and $v=$ the excess of the attractive force over the ethereal repulsion developed by the attraction; all the forces being considered as taking effect upon the central atom. The effective action exerted by either molecule upon the other will be the difference between the values of u and v. Denote it by f; then $f=v-u$. When the calculated value of f is positive the action will be attractive; when it is negative the action will be repulsive. We have for the force of attraction the general expression $\frac{n}{(r+x)^2}$; for the ethereal repulsion the expression $\frac{n}{(2r+x)^2}$; and for the electric repulsion $\frac{m}{x^2}$. Then

$$v=\frac{n}{(r+x)^2}-\frac{n}{(2r+x)^2}=\frac{n(3r^2+2rx)}{(r+x)^2(2r+x)^2} \quad . \quad . \quad . \quad , \quad (1)$$

$$u=\frac{m}{x^2} \quad . \quad . \quad (2) \qquad f=v-u=\frac{n(3r^2+2rx)}{(r+x)^2(2r+x)^2}-\frac{m}{x^2} \quad . \quad . \quad (3)$$

As the two forces of electric attraction and repulsion have an

TABLE I.

$f=0$, when $x=20r$.		$f=0$, when $x=10r$.		$f=0$, when $x=5r$.		$f=0$, when $x=3r$.		$f=0$, when $x=2r$.	
$n=12{\cdot}410m$		$n=7{\cdot}576m$		$n=5{\cdot}428m$		$n=4{\cdot}938m$		$n=5{\cdot}143m$	
x	f	x	f	x	f	x	f	x	f
$0{\cdot}5r$	$-0{\cdot}470\ k$	$0{\cdot}5r$	$-1{\cdot}8450\ k$	$0{\cdot}5\ r$	$-2{\cdot}4560\ k$	$2{\cdot}0r$	$-0\ 00996k$	$1{\cdot}8\ r$	$-0\ 00881k$
0·6	+0·2341	0·7	−0·4586	1·0	−0·2461	2·5	−0·00075	1·9	−0·00361
0·7	+0·5510	0·9	−0·0368	1·5	−0·01906	2·7	−0·00001	1·95	−0·00164
0·9	+0·7275	1·0	+0·0522	1·672	0·00000	2·8	+0·00009	2·0	0·00000
1·0	+0·7236	1·2	+0·1310	1·7	+0·00207	2·9	+0·00008	2·1	+0·00246
1·3	+0·6146	1·3	+0·1447	2·0	+0·01386	3·0	0·00000	2·2	+0·00408
1·4	+0·5709	1·4	+0·1497	2·2	+0·01576	3·2	−0·00034	2·3	+0·00508
1·5	+0·5360	1·5	+0·1492	2·25	+0·01585	3·5	−0·00102	2·4	+0·00563
2·0	+0·3533	1·7	+0·1398	2·3	+0·01584	4·0	−0·00215	2·5	+0·00586
5·0	+0·0514	2·0	+0·1188	2·5	+0·01506	5·0	−0·00360	2·7	+0·00568
10·0	+0·0064	4·0	+0·0301	2·75	+0·01322	6·0	−0·00416	3·0	+0·00460
15·0	+0·00109	5·0	+0·0158	3·0	+0·01102	7·0	−0·00421	4·0	+0·00036
20·0	0·00000	7·0	+0·00444	4·0	+0·00384	8·0	−0·00404	4·1	+0·00003
25·0	−0·000265	10·0	0·00000	5·0	0·00000	9·0	−0·00377	4·5	−0·00109
30·0	−0·000317	15·0	−0·00107	6·0	−0·00181	10·0	−0·00349	5·0	−0·00211
35·0	−0·000306	20·0	−0·00097	7·0	−0·00280	15·0	−0·00224	7·0	−0·0036
40·0	−0·000280	30·0	−0·00061	8·0	−0·00289	20·0	−0·00150	8·0	−0·0036
80·0	−0·000110	40·0	−0·000413	9·0	−0·00292	40·0	−0·000487	10·0	−0·0032
		80·0	−0·000128	10·0	−0·00283	80·0	−0·000138	15·0	−0·00215
				15·0	−0·00202			20·0	−0·00146
				20·0	−0·00141			40·0	−0·000481
				40·0	−0·00047			80·0	−0·000137
				80·0	−0·000136				

entirely different origin, we have no reason to suppose that $n=m$; nor have we any means of ascertaining, on *à priori*

grounds, their comparative values. But we can assume that $u=v$, for some supposed value of x, determine the ratio of n to m on this supposition, and calculate the values of f for various values of x, both greater and less than that for which we have taken $f=0$.

The preceding table contains the results of numerous calculations made after this manner: in which k stands for $\frac{m}{r^2}$.

From these results it appears that for values of $\frac{n}{m}$ greater than 4·938, or thereabouts, there are *two alternations of the effective force f, as the distance between the molecular atmospheres increases indefinitely from zero.* The first is from a repulsion to an attraction; the second is from an attraction to a repulsion. The repulsion which becomes effective beyond the limit of the attraction, at first increases, and then decreases, extending to an indefinite distance. If the ratio, $\frac{n}{m}$, be less than about 4·938, the effective action of the two molecules upon each other will be repulsive at all distances. It will be observed also that the range of distance within which an attractive force takes effect is greater in proportion as the value of $\frac{n}{m}$ is greater, and that this becomes reduced nearly to zero, when this ratio is equal to 4·938; also, that in all cases in which an effective attraction manifests itself at any distance whatever between the molecules, that is in the case of every known solid and liquid, the effective repulsion within the limit of the attraction, obtains at less distances between the electric atmospheres of the molecules than about $3r$, that is, than once and a half the diameter of either atmosphere.

For the more accurate determination of the least value of the ratio $\frac{n}{m}$, we have the following results of computation:

For $f=0$, when $x=3r$, $\frac{n}{m}=4·93827$; for $f=0$, when $x=2·9r$, $\frac{n}{m}=4·93449$; for $f=0$, when $x=2·8r$, $\frac{n}{m}=4·934409$; for $f=0$, when $x=2·7r$, $\frac{n}{m}=4·93847$. If then the ratio $\frac{n}{m}$ be greater than 4·9344, the two alternations of effective molecular force above mentioned will have place; if the ratio be less than 4·9344, the effective action of the one molecule upon the other will be repulsive at all distances.

It is assumed in the foregoing calculations, that the surface of each molecular atmosphere which receives the impulses, whether attractive or repulsive, propagated from the other through the intervening electric ether, may be regarded as the same as that

from which the electric repulsion proceeds outward, but it will be readily seen that they may be supposed to differ within certain limits, without vitiating the result that for certain values of $\frac{n}{m}$ two alternations of the effective force will subsist. The forces may also experience losses, to a certain extent, in their propagation, and this general principle still hold good.

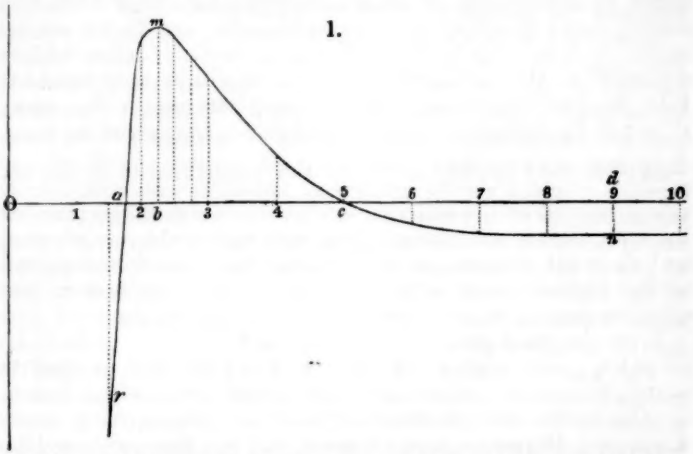
It should also be observed that when two particles are remote from each other, as in the case of a particle of cometic matter repelled by the sun, we must suppose the intervening space to be occupied by the universal ether only. In such a case, then, both the attractive action and the *electric* repulsion will be wanting; and the only force remaining will be the *ethereal* or *heat-repulsion;* which should operate at indefinite distances, according to the law of inverse squares. A discussion of the phenomena of evolution of cometary envelopes, and of the outstreaming of jets of nebulous matter from particular parts of the surface of the nucleus, must be had before we can decide how far the *electric* repulsion may be in operation in the processes of ejection of cometic matter from the nucleus.[2]

The general law of the variations of the force of effective molecular action is graphically represented by the curve r, a, m, c, n, in fig. 1. The abscissas represent the comparative distances between the electric atmospheres of the two molecules, and the ordinates the intensities of the effective force corresponding to these distances. When the ordinate lies above the axis of abscissas, the force is attractive; when it lies below, the force is repulsive. The two axes are asymptotes to the curve. The curve has been constructed from the calculated results obtained on the supposition that $f=0$, when $x=5r$.

There are four points, marked a, b, c, d, to be especially noted. a and c, where $f=0$, represent positions of equilibrium; a being a position of stable, and c of unstable equilibrium. When the atmospheres are separated by the distance Ob the attraction has its maximum value, bm; and when they are at the distance Od, the repulsion, beyond the outer limit of the attraction, has its maximum value, dn. In order that two particles may unite, when influenced by their own proper forces only, the distance

[2] In the memoir by the author "On the Theoretical Determination of the Dimensions of Donati's Comet," published in No. 87, vol. xxix, and in No. 94, vol. xxxii, of this Journal, the conclusion was reached, as one result of the computations, that "the repulsion exerted by the sun, and also by the nucleus (of the comet), is not a property belonging to all the particles of the mass, like the attraction of gravitation; and is probably, therefore, a force emanating from the surface of the body, or from a portion only of its mass." We now see that the existence of such a force is also a legitimate deduction from the theory of molecular forces under consideration; and that it consists in the force of ethereal repulsion, which we have denominated *heat-repulsion*. Its impulses constitute the entire force of radiant heat given off by the body into free space, and vary in intensity, or amount, with the temperature.

between their atmospheres must be less than O*c*. But if they are subject to an external pressure urging them toward each other, it suffices that this pressure should exceed the maximum repulsion *dn*, at the greater distance O*d*. To separate the particles the force in operation must exceed in intensity the maximum molecular attraction, *bm*.[3]



If heat be imparted to the two particles under consideration, it will obviously tend to depress the entire curve of molecular action, and diminish the range, *ac*, of the attractive force. If the amount be continually increased, the distances between the two positions of equilibrium, *a* and *c*, will eventually be reduced to zero, and the curve thrown entirely below the axis of abscissas, or the effective force become a mutual repulsion at all intervals of distance between the particles. This would be the necessary tendency of the introduction of new repulsive impulses into the system, even if the original forces continued in full operation as before; but, heat, by expanding the molecular atmospheres, should also tend to diminish the ratio of *n* to *m*, and therefore to modify in a similar manner the natural curve of molecular action.

It is easy to see that a similar curve will also serve to represent the mutual actions of dissimilar molecules, which obtain

[3] To guard against misapprehension it may be well to observe here, that the resisting force of cohesion which is brought into play when a body is ruptured by a pulling force is not necessarily proportional to the intensity of the maximum force of attraction between two of its particles. For it must depend, not only upon the intensity of this attraction, but also, on the number, distance, and position of the other particles that oppose, by their attractive action, the separation of the two. Incidentally the displacement these particles may experience, from the action of the rupturing force, comes in as a modifying cause.

when a chemical union is formed between two different substances. But in this case a force of electric attraction not yet considered may come into play.

The general principle of two alternations of the effective action of molecules, to which we have been theoretically conducted, is distinctly recognized as a physical fact in the three different states of aggregation of matter;—in the molecular attraction and repulsion manifest in solids and liquids, and in the mutual repulsion subsisting between the same particles when widely separated in the vaporous condition. It will be seen hereafter that the law of molecular action, as portrayed in the curve shown in fig. 1, furnishes, in the probable variations of the ratio, $\frac{n}{m}$, an adequate general cause for the varied results of this action exhibited in the different properties of substances; and at the same time reveals the probable explanation of many physical and chemical phenomena, occurring at surfaces of contact, and of the dependence of these phenomena upon temperature and other circumstances, as in oxydation, combustion, &c.

From the stand-point now taken new views open up to us on all sides. The more conspicuous of these we will proceed to sketch, in general outline, under the several heads of the *Molecular Constitution and Mechanical Properties of Bodies*, *Heat*, *Light*, *Electricity*, *Magnetism*, and *Chemical Action*. The intimate relations subsisting between the phenomena occurring in these different departments of Nature, and between the special agents by which they are produced, or the "correlation of the physical forces," will be seen to be deducible from the fundamental conceptions adopted. It will be observed that all these varied phenomena are but different results of the action of the primary forces, which consists in an attraction of atoms for their atmospheres, and in a mutual repulsion between the atoms of these atmospheres;—that they are, primarily, movements or disturbances, produced in these subtile atmospheres, from which ethereal waves of impulses, and motions of molecules and masses, may result.

Molecular Constitution, and Mechanical Properties of Bodies.

Every body of matter consists of separate particles, or molecules, in a state of equilibrium under the action of the forces proper to the particles, or of these in connection with extraneous forces taking effect upon the particles. The interstices between the molecules we conceive to be pervaded by both the electric and the universal ether; having, probably, different densities in different substances. The state of equilibrium in which each particle of the mass subsists, implies that the effective forces acting upon it, from opposite sides, are equal and directly opposed, or else that the effective forces of each side are equal to zero. The

different mechanical properties of different substances may be ascribed, primarily, to differences in the value of the ratio of the constants of electric attraction and repulsion ($\frac{n}{m}$, in Table I); and to a certain extent also to differences in the size of the molecular atmospheres, upon which the value of k in Table I. partly depends. In consequence of these supposed differences in the value of the ratio, $\frac{n}{m}$, each substance should have its own special curve of molecular action. It is natural to suppose that the constant, n, of the force of attraction exerted by the atom upon its atmosphere would in general increase with the mass of the atom, and so that the force of cohesion would be greatest in those substances whose atomic weights are the greatest. But as we cannot affirm that the weight of an atom must necessarily be proportional to the force of attraction exerted by it upon its electric atmosphere, and as the constant, m, may also be subject to variations, substances of nearly equal atomic weights (e. g., gold, platinum, bismuth, and lead) may have different properties.

The molecules of a substance in the solid state may be aggregated together as a homogeneous mass, or in groups more or less complex. The mechanical properties of the mass vary with the mode of aggregation. The form of aggregation assumed, in the process of solidification, depends upon the circumstances, with respect to cooling, pressure, &c., under which the solidification occurs. The effect of the same circumstances should vary with different substances, with their properties in relation to heat; but these properties are primarily dependent upon the general features in the constitution and condition of the molecules, upon which the laws of effective molecular action, as shown by the proper curve, depend.

'Contemplating, from our present point of view, the varying mechanical states and conditions which the same substance may assume under different circumstances, we are led to recognize, as an essential physical feature, upon which such changes either wholly or partially depend, the fact that the mechanical condition of the individual molecules is not fixed and unchangeable, but liable to material variations. We perceive their atmospheres expanding under the influence of heat, and contracting from the effect of external pressure, and that certain phenomena and permanent changes of property result from these atmospheric changes; (e. g., changes of property in passing from the solid to the liquid form, or vice versa; permanent displacement of particles produced by the temporary action of forces of a certain intensity, upon bodies).

States of Aggregation of Matter.—These are three essentially different states of equilibrium. In the *solid* form, the particles immediately contiguous to each other are in a condition of equilibrium under the action of their own molecular forces; if more distant particles exercise any effective action, it is attractive, and neutralized by a similar action on the other side of the particle. To be more definite, each molecule of the mass is surrounded by others at various orders of distance from it; and each pair of molecules at the first order of distance from each other are in a condition of equilibrium by themselves, which is equivalent to saying that their electric atmospheres are separated by the distance Oa, fig. 1. For the second order of distance the action should then be attractive, but it may very well be that when a permanent equilibrium of the mass has been reached, the atmospheres of two particles at this order of distance will be so expanded by their attractive action, on the line of their centres, that, for the diminished value of $\frac{n}{m}$ thus resulting, the distance between the atmospheres on this line will be the increased distance Oa for the curve corresponding to this diminished value of $\frac{n}{m}$. Upon this supposition, each particle would be separately in equilibrium with every particle contiguous to it, both at the first and second order of distance. We shall have occasion to note hereafter that this state of things is probably more or less perfectly realized under different circumstances of solidification. As to the action of more distant molecules, it is first to be observed that if two molecules are in equilibrium, under their mutual actions, the attractive and repulsive impulses exerted by each upon the central atom of the other, must be equal, and therefore that no effective action, either attractive or repulsive, can be transmitted to other more distant particles on the same line. Under these circumstances, one molecule, in receiving the action of another, *intercepts* the action that would otherwise take effect upon other more distant molecules. This being admitted, it may be perceived, on examining Table I, that the attractive actions of particles which lie beyond the second order of distance from a given particle, will be in a great measure intercepted by intervening particles. In what has now been stated with respect to the solid condition, we have had in mind a homogeneous mass of molecules only. We cannot here enter upon the consideration of the case in which the molecules are aggregated into groups.

In the *liquid* state, the contiguous particles repel each other; and particles more distant exert no sensible action, or a feeble attractive one. Here, as in the case of a solid, the sensible action is confined chiefly to particles that lie at the first and sec-

ond orders of distance. These remarks apply to the general mass of the liquid. The molecular atmospheres are in an expanded condition from the effect of the heat of fluidity, and it is from this fact that the peculiar properties of the liquid state result. As we draw near the surface of the liquid, the atmospheres are in a condition of greater and greater expansion as the necessary result of the process of liquefaction, and therefore their proper attractive actions are less and less. From this cause it happens that each particle near the surface is more effectively attracted by those below it, beyond the first order of distance, than by those above it, and thus each layer of particles is compressed upon that immediately below it; also to a certain depth more particles will exert their attraction from below than from above. As a consequence, the density must increase from the surface to a certain small depth below it, and a force of compression be exerted throughout the whole liquid mass. This force determines, and is in equilibrium with, a mutual repulsion between the particles of the liquid. From the essential nature of a liquid, as we shall soon see, this increasing molecular repulsion, from the surface downward, operates in all directions from each molecule, and so tends to neutralize the attractive actions between molecules separated by the second order of distance; as the final result, therefore, at the depth at which the density ceases to increase, and all greater depths, the action between two such molecules should be either feebly attractive, or altogether evanescent.[4]

The views which have now been presented enable us to form a definite conception of the probable arrangement of the molecules of a liquid. If the state of equilibrium be such as we have represented, we must conclude that a perfectly symmetrical arrangement of particles, similar to that which subsists in crystals, prevails throughout the whole mass.

We conceive the fundamental distinction between a solid and a liquid, from the mechanical point of view, to be that the external impulses which fall upon the molecule of a solid, are propagated, either wholly or chiefly, in their original line of direction; while those which fall upon the molecule of a liquid are radiated in every direction from it. The physical cause of this difference in the mode of propagation of a force appears to be the simple fact that in the process of liquefaction the molecular atmospheres are forced by the heat of fluidity to a decidedly greater distance from the atoms which they surround; thus, leaving below them a much larger volume of universal ether, to

[4] The theory of the existence of a contractile force at the surface of a liquid, as the result of molecular action, was advocated by Young and Poisson, and employed by them in explanation of the phenomena of capillarity. It has also been ably sustained and illustrated by Professor Henry, by many ingenious experiments.

receive the impulses propagated down to it. If this difference between the mode of propagation of impulses by the molecules of a solid and liquid be admitted, it is not difficult to see that we have a sufficient cause for the different mechanical properties attendant upon these two states of aggregation, without having recourse to the prevalent idea of a permanent polarity of simple atoms. So far as any polarization of molecules comes into operation, we shall have occasion to remark in discussing briefly the topic of crystallization, that it is simply an induced, and for the most part a temporary condition of the molecular atmospheres, developed in the act of solidification.

In the *aëriform* state the particles are so widely separated that each is repelled by all those which surround it, within the limit of effective action, and the equilibrium is determined by external pressure. The properties of gases and vapors, and the laws of their expansion and contraction, are deducible from equ. (3) (p. 68). The value of x that obtains when a vapor formed at any temperature has its maximum tension, is the distance Od, fig. 1, answering to the maximum molecular repulsion, dn; and this varies for different temperatures because the ratio, $\frac{n}{m}$, decreases as the temperature rises. (See different values of maximum repulsion answering to different values of the ratio $\frac{n}{m}$, given in Table I.)

The process of transition from the solid to the liquid state occurs at the surface of the mass. As the heat is absorbed, the molecules near the surface recede from each other; and when this expansion has reached a certain point, the attractive forces of the particles at the different orders of distance come successively into action, being less intercepted by intervening particles. At the same time, the individual molecular atmospheres expand, or recede from their central atoms, under the action of the heat pulses that penetrate to these atoms; and so the energy of the attractive force of each of these molecules declines. The surface particles will thus continue to recede at the same time that they are restrained by the attractions of those below them. This effect will extend from the surface downward; and as a final result, a certain number of layers are brought into the liquid condition, in which, as we have seen (p. 75), the particles mutually repel each other, in consequence of the exertion of a compressing force at the surface. In the case of a liquid that emits vapor at the temperature of liquefaction, we must conclude that the particles at the very surface become ultimately subject to an effective repulsion from the united action of those below it, which is in equilibrium with the tension of the vapor resting on the surface; and that this effective repulsion extends to all points above the surface.

The heat of fluidity is consumed in forcing up the molecular atmospheres. As a final result of the liquefaction, these atmospheres remain in an expanded condition. The effect of this expansion is to diminish the values of v given by equ. (1) (see p. 68), and increase the distance Oa, fig. 1. The actual distance between two contiguous atmospheres is less than the increased distance Oa, by reason of the compressing force that takes effect throughout the liquid mass. But the ultimate compression imparted to the individual atmospheres will depend in a great degree upon the final value of the attractive action, v, between the molecules, and may therefore still be less than that which obtained in the solid state. In this diminished value of v we have, at the same time, the explanation of the diminished force of cohesion attendant upon the liquid state. The comparative densities of the liquid and solid also depend upon v. For we have just seen that the distance between the contiguous atmospheres of two particles of the liquid is less than the increased value of Oa, but this distance may, according to the intensity of the attractive force, v, be either greater or less than the original value of Oa; which was the distance between the atmospheres of the same particles in the solid condition. Accordingly, the liquid may be either more or less dense than the solid from which it is derived.

The passage from the liquid to the solid state is, essentially, the inverse of that which has just been under consideration, and in the general survey we are now taking need not be considered in detail. The mass of molecules and their individual atmospheres now contract instead of expanding, and in the final act of solidification the contiguous molecules assume the positions due to their own special forces. While all this is being accomplished, the molecular atmospheres contract, and heat is given out.

The explanation of the process of *evaporation* will be readily inferred from what has already been stated with regard to the condition of the surface of a liquid (p. 76). The nice equipoise of the surface particles may be disturbed either by a slight elevation of temperature, or a diminution of the tension of the vapor resting upon them. The cooling effect of the evaporation is to be attributed to the expansion which the electric atmospheres experience, on being freed from the compressing forces previously existing.[8]

[8] It is apparently not necessary to suppose, as has been done on page 76, that the tension of the vapor resting on the surface of a liquid, when at its maximum, is in equilibrium with the outward repulsion experienced by the outer layer of liquid particles. The equilibrium may be a dynamical one; the vapor may be continually rising at certain points of the surface, and continually passing back into the liquid condition at other points,—the condensation compensating exactly for the evaporation.

In the process of *ebullition*, the expansive action of the heat absorbed by the lower layers of the liquid increases until the superincumbent pressure, the cohesive attraction of the vessel for the liquid, and the effective attractions subsisting between the molecules of the liquid (represented by the ordinates between *a* and *b*, fig. 1), are overcome. When this point is reached at any part of the liquid stratum, the separated particles will expand rapidly into bubbles of vapor, in opposition to the pressure of the atmosphere, and the attractions denoted by the decreasing ordinates between *b* and *c*, fig. 1. The expansion should continue until the distance between the atmospheres of two particles increases to the limit O*d*, at which the repulsion attains to its maximum value; or rather to a limiting distance somewhat greater than O*d*, at which the repulsion due to the heat pulses present in the molecules, *plus* the molecular repulsion at that distance, is equal to the external pressure.

It cannot proceed further than this without a direct expenditure of heat-force, which will raise the temperature of the vapor. The heat which becomes latent, as the phrase is, is expended in the act of expansion, and in forcing up the molecular atmospheres in opposition to the attractive action of the atoms and all compressing forces. The amount of work thus taken up by the atmospheres manifests itself also as work of expansion, since it is so much work of the atomic attraction and of the compressing forces neutralized. When the heat pulses are not wholly expended in this manner, a portion of them pass into the molecular atmospheres and elevate the temperature of the liquid. If the pressure upon the free surface of the liquid exceeds the pressure of the atmosphere, the molecular atmospheres are more compressed, the value of m becomes greater, and the ratio, $\frac{n}{m}$, diminishes in consequence; from this cause the limit of the recess of the particles, O*d*, fig. 1, diminishes, and the maximum repulsion, *dn*, increases (see Table I). The resulting vapor has, therefore, at the same time, a higher tension and a greater density.

According to the theoretical views now advanced, the "interior work" which Tyndall maintains is expended in the act of liquefaction, and also in that of vaporization, in "moving the atoms into new positions," or in conferring "potential energy" upon them, is consumed in each instance in pressing up the electric atmospheres that surround the atoms of the substance; and heat disappears in the process in proportion to the effect thus produced.

[To be continued.]

ART. VIII.—*On the Improvement of the Elements of a Comet's Orbit: Brünnow's method;* communicated by C. ABBE.

THE following method of conducting the computation of the elements of a parabolic orbit was taught by Dr. Brünnow in lectures at the University of Michigan in 1858; it is here faithfully reproduced from my notes taken at that time, and whatever of merit it possesses is of course due to my instructor. The formulæ are thrown into the natural order of computation, and they will thus be readily available to the computer. The present is quite a general method: it presumes a previous approximate knowledge of the orbit, and is suited to normal places or very exact observations, and is not limited to the use of three places. The intervals $t''-t'$ and $t'-t$ are not restricted.

We use at least three complete observations, i. e., the times t, t', t''; the geocentric longitudes λ, λ', λ'', and the geocentric latitudes β, β', β''. We shall also need the sun's geocentric longitudes $\odot$, $\odot'$, $\odot''$, and the logarithms of the sun's geocentric distances R, R', R''. From our previous knowledge of the orbit we shall have been able to correct our observations for velocity of light, aberration and parallax; they should be referred by proper corrections for nutation and precession to the same equinox.

We first may prepare the angles

$$\odot''-\odot, \quad \lambda-\odot, \quad \lambda''-\odot,$$

the number R, and the logarithm of $t''-t$.

Compute the number g and angle G from

$$\begin{aligned} R'' \cos(\odot''-\odot)-R &= g\cos(G-\odot) \\ R'' \sin(\odot''-\odot) &= g\sin(G-\odot) \end{aligned}$$

g and G are the distance and longitude of the first place of the earth as seen from the third.

Compute the numbers c and c'' and logarithms C and C'' from

$$\begin{aligned} \cos\beta\cos(\lambda-\odot) &= \cos\psi & \cos\beta''\cos(\lambda''-\odot'') &= \cos\psi'' \\ R\cos\psi &= c & R''\cos\psi'' &= c'' \\ R\sin\psi &= C & R''\sin\psi'' &= C'' \end{aligned}$$

ψ and ψ'' are the angles at the earth between the sun and comet at the first and third observations.

From our previous knowledge of the orbit we now assume two values Δ and Δ_1 of the distance between the comet and earth at the time t. It will be a little more convenient and elegant to assume $\log\Delta$ and $\log\Delta+i$. The following computation is to be made for each assumption. Compute $\log D$ and angles B and L from

$$\begin{aligned} \Delta\cos\beta\cos(\lambda-G)+g &= D\cos B\cos(L-G) \\ \Delta\cos\beta\sin(\lambda-G) &= D\cos B\sin(L-G) \\ \Delta\sin\beta &= D\sin B \end{aligned}$$

D, B, L, are the distance, latitude and longitude of first comet's place as seen from third earth.

Compute the number a and logarithm A from

$$\begin{aligned} \sin\beta'' &= n^* \sin m \\ \cos\beta'' \cos(\lambda'' - \mathrm{L}) &= n \cos m \\ n \cos(\mathrm{B} - m) &= \cos\varphi \\ \mathrm{D}\cos\varphi &= a \\ \mathrm{D}\sin\varphi &= \mathrm{A} \end{aligned}$$

Compute the number r from

$$r = +\sqrt{(\Delta - c)^2 + \mathrm{C}^2} = \frac{\Delta - c}{\cos x} \text{ if we put } \tan x = \frac{\mathrm{C}}{\Delta - c}$$

r is the heliocentric distance of comet at the first observation. We now desire to find r'', which must be accomplished by a tentative process.

Assume a value, Δ'', of the distance of third comet from third earth. Compute the number r'' from

$$r'' = +\sqrt{(\Delta'' - c'')^2 + \mathrm{C}''^2} = \frac{\Delta'' - c''}{\cos x} \text{ if we put } \tan x = \frac{\mathrm{C}''}{\Delta'' - c''}.$$

With the r and r'' thus found we compute logarithm $\varkappa$ from Lambert's equation, as follows:

$$[8{\cdot}5366114]\ \frac{t'' - t}{(r'' + r)^{\frac{3}{2}}} = \eta$$

$$\frac{3\eta}{\sqrt{8}} = \sin\beta$$

$$\frac{3\sin\frac{1}{8}\beta}{\sin\beta}\sqrt{\cos\tfrac{2}{3}\beta} = \mu$$

$\log\mu$ is tabulated with argument η. (See Davis's *Gauss Theoria.*)

$$\varkappa = \eta\mu\,(r'' + r)$$

If this value of $\varkappa$ does not agree with that found from

$$\varkappa = +\sqrt{(\Delta'' - a)^2 + \mathrm{A}^2} = \frac{\Delta'' - a}{\cos x} \text{ if we put } \tan x = \frac{\mathrm{A}}{\Delta'' - a}$$

we must then assume another value of Δ'' and renew the computation of $\varkappa$. A few trials will give the required value of Δ''. $\varkappa$ is the chord between the first and third places of the comet.

We are now able to find the heliocentric distances r and r'', latitudes b and b'', and longitudes l and l'', of the first and third positions of the comet, from the following formulæ:

$$\begin{aligned} \Delta\cos\beta\cos(\lambda - \odot) - \mathrm{R} &= r\cos b\cos(l - \odot) \\ \Delta\cos\beta\sin(\lambda - \odot) &= r\cos b\sin(l - \odot) \\ \Delta\sin\beta &= r\sin b \end{aligned}$$

* Sign of n is plus.

and

$$\begin{aligned} \Delta'' \cos\beta'' \cos(\lambda'' - \odot'') - R'' &= r'' \cos b'' \cos(l'' - \odot'') \\ \Delta'' \cos\beta'' \sin(\lambda'' - \odot'') &= r'' \cos b'' \sin(l'' - \odot'') \\ \Delta'' \sin\beta'' &= r'' \sin b'' \end{aligned}$$

The values of r and r'' found from these formulæ must agree with those found previously.

Having now the heliocentric coördinates of the comet for the times t and t'', we are able by well known formulæ to find the elements of the orbit, and from these elements we compute the latitude and longitude for the time t'. A comparison of these results with the observed β' and λ' will show that

the assumption of $\log\Delta$ gives $\lambda'+a$ and $\beta'+b$
" " $\log\Delta+i$ " $\lambda'+a'$ " $\beta'+b'$

but

" " $\log\Delta+x$ must give λ' " β'

therefore neglecting second differences we must have

$$a - \frac{a'-a}{i}\,x = 0 \qquad\qquad b - \frac{b'-b}{i}\,x = 0.$$

From as many such equations as we choose to employ we may determine x, and a new computation assuming $\log\Delta+x$ as the logarithm of the distance between first comet and first earth, will lead to our desired improved elements.

ART. IX.—*Notes on the Platinum Metals, and their Separation from each other;* by M. CAREY LEA, Philadelphia.—Part I.

(I.)

FEW branches of inorganic chemistry present difficulties comparable with those involved in the study and separation of the platinum metals. Their close analogy with each other, and the remarkable manner in which the relations of each to chemical reagents are controlled by the presence of the others, give rise to difficulties in their detection and separation which are only by degrees being surmounted. Much time and unwearied labor on the part of the chemist are required to reach results which when obtained appear insignificant in proportion to the effort which they cost, and it may in fact be said that the platinum metals constitute a chemistry in themselves, governed by special rules and to be studied by special methods. Each step in the simplification of the processes by which the separations are effected, each decisive reaction by which the presence or absence of a member of the group may be certainly inferred, is so much gained toward conquering a complete knowledge of these rare and interesting bodies.

For much the better half of all we know upon this subject, we are indebted to Dr. Claus, whose method of separation I have followed up to a certain point, and then have diverged from it, with I think some advantage. I propose to introduce the use of *oxalic acid*, as an agent in effecting the separation, in the manner which I shall presently describe.

From my friends, Prof. Booth, of the U. S. Mint, and Mr. Garrett, I received the material upon which I have worked. This was Californian osmiridium, which had already undergone a preliminary fusion with nitre and caustic potash.

This material was next boiled with aqua regia to extract all the soluble portions, the residue was then ignited with nitre and caustic soda,[1] the fused mass was heated with water. From the resulting solution small portions of osmite of potash crystallized out. The metallic oxyds were next precipitated, and this precipitate, together with the portions insoluble in water, was boiled again with aqua regia, ignited again, &c. These ignitions, in addition to that which it had undergone before coming into my hands, still left a small portion of unattacked residue.

The boiling with aqua regia was continued for a very long time in order to get rid as thoroughly as possible of the osmic acid; in all, this treatment was extended over two hundred hours. Even this however still left osmium in the solution, in easily recognizable but in comparatively small quantity. The greatest advantage was found throughout the whole of this part of the operation from the use of the blowing apparatus, which I described in a former number of this Journal, and with the aid of which all inconvenience from the fumes of osmic acid was avoided. The apparatus was constantly swept clear by a powerful air-current, and the osmic acid was removed as fast as it volatilized. The treatment which the ore had undergone before it was placed in my hands, had removed the greater part of the osmium; a portion of what remained had separated out as osmite of potash, and it was not deemed worth while to attempt to save the little that remained. It would be easy, however, in operating upon fresh material with the aid of this blowing apparatus, to conduct the osmic fumes through an appropriate reducing agent, and at the same time to sweep out every trace which escaped reduction. As the ignition of the ore with alkaline nitrate and caustic scarcely drives off any osmium, and as almost all inconvenience in manipulating the resulting solutions can be avoided by throwing down the metals with alcohol from

[1] Attention is necessary to the order in which these substances are employed. If the caustic soda is melted first, it attacks the iron vessel strongly and may even go through. If added last, it causes sudden and violent effervescence, with danger of boiling over. Therefore, place the nitre first in the vessel, and when it is fused, add the caustic soda. When a red heat is attained, add the osmiridium by degrees.

the hot alkaline solution, in place of using acid, it is clear that the difficulties arising from the noxious effects of osmic acid can be almost wholly removed from each of the various stages of the process.

A very prolonged treatment with aqua regia was found to have the great advantage of converting nearly the whole of the ruthenium into bichlorid. The separation of ruthenium in this form from the other metals is so easy in comparison with the difficulties presented by the separation of the sesquichlorid, that this advantage cannot be looked upon as other than a very material one.

Salammoniac was next added to the mixed solution in quantity sufficient to saturate it. The sandy crystalline precipitate (A) was thoroughly washed out, first with saturated, and then with dilute salammoniac solution. The saturated solution of ammonium salt carried through with it nearly the whole of the ruthenium as bichlorid (B), the dilute solution was found to contain small quantities of iridium, rhodium, and ruthenium (C).

Over (A), water acidulated with chlorhydric acid was placed, and allowed to stand for some days. This was treated with ammonia and boiled. The precipitate was inconsiderable, and, when treated with chlorhydric acid, furnished green chlorid of osmium, with traces of ruthenium.

In these preliminary steps I have used Claus' process, which undoubtedly offers advantages over any other, and best brings the metals into a convenient state for separation, varying it only by prolonging the treatment with aqua regia, and converting the ruthenium principally into bichlorid instead of sesquichlorid. We have now three portions of material, (A) consisting of iridium salammoniac, containing also ruthenium, osmium, rhodium, and platinum in small quantities. (The ore which I examined contained no palladium, which metal, if present, has always its own peculiar mode of separation, and does not enhance the difficulties of the operation.) (B) containing bichlorid of ruthenium, together with iron in quantity, copper, and other base metals which may be present. Finally, (C) containing chiefly bichlorid of ruthenium, mixed with small quantities of iridium and rhodium.

The next step in the process is to introduce the iridium-salammoniac (A) into a large flask with twenty to twenty-five times its weight of water, and apply heat until the solution is brought to the boiling point; the whole of the iridium-salammoniac should be brought into solution in order that the reduction to be operated may not occupy too long a time, as otherwise the platinum and ruthenium salt, if any be present, might likewise be attacked. Crystals of oxalic acid are thrown in as soon as the solution actually boils, whereupon a lively effervescence

takes place, and the iridium salt is rapidly reduced. As fast as the effervescence subsides, more oxalic acid is added until further additions cease to produce any effect. When this is the case, the liquid is allowed to boil for two or three minutes longer, not more; the heat is to be removed, and the flask plunged into cold water.

By this treatment any platinum present is unaffected. Sal-ammoniac in crystals is added, about half enough to saturate the quantity of water present. The salammoniac may be added immediately before the flask is removed from the fire. After cooling, the solution should be left for a few days in a shallow basin, whereby the platinum salammoniac will separate out as a yellow, a reddish, or even (especially if the quantity of water used was insufficient) as a black crystalline powder, according to the quantity of bichlorid of iridium which it may contain.

The mother water is to be again placed in a flask and boiled with aqua regia. On cooling, the platinum salammoniac crystallizes out, and any traces of rhodium and ruthenium which may be present remain in solution. The iridium salt is to be washed with a mixture of two parts saturated solution of salammoniac and three parts of water, and may then be regarded as pure.

The treatment by oxalic acid, which is now proposed for the first time, affords iridium free from all traces of ruthenium. The detection of very small quantities of ruthenium in presence of much iridium has been hitherto an impossibility, or could only be effected by Claus' method of allowing a small quantity of water acidulated by chlorhydric acid to remain in contact with the iridium salammoniac for some days. The ruthenium salt, by its superior solubility, tended to dissolve first, hence the acidulated water after standing contained ruthenium in larger relative proportion than the original crystals—the ruthenium reactions were more marked, and if it was present and in sufficient quantity, it could be detected by sulphocyanid of potassium, or better, to an experienced eye, by acetate of lead. The objections to this method are sufficiently obvious. I shall presently describe a reaction which will detect ruthenium in the presence of any quantity of iridium, and, scrutinized by that test, the iridium prepared in the manner which I have just described, is free from ruthenium, as well as from the other more easily separable cognate metals.

The treatment of solutions (B) and (C) presents no difficulty. With (B) the best plan is to place the solution aside in a beaker covered with filter paper for some time. Treated in this way the bichlorid gradually crystallizes out, and by recrystallizations may be obtained in a state of perfect purity.

Solution (C) is to be evaporated to dryness and reduced to an impalpable powder. It is then to be thrown upon a filter and

thoroughly washed with a perfectly saturated solution of sal-ammoniac. The bichlorid of ruthenium is thus carried through, with perhaps a trace of sesquichlorid of rhodium, from which, however, it is easily freed by crystallization. From the residue, the sesquichlorid of rhodium and ammonium, $3NH_4Cl$, Rh_2Cl_3 $+3HO$, is removed by a dilute solution of salammoniac, perfectly free from the iridium, which is left behind.

In connection with this separation I may make a remark, which, though of special reference to this particular case, is also applicable to all those cases in which the double chlorids of the platinum metals are to be separated by their various solubilities in solution of salammoniac. This most valuable process, in which we are indebted as for so much else, to Claus, whose untiring labors have made him the father of this department of chemistry, requires to be applied with some attention to minutiæ. The crystalline matter must be reduced to the finest powder, and after being thrown upon the filter, it must be washed continuously until the separation is effected. Any interruption of the washing is followed by more or less crystallization of salammoniac through the material which precludes an effectual separation. The same material which in a state of coarse powder will hardly yield up enough $RuCl_2$ to color the salammoniac solution, will, when thoroughly pulverized, give an almost opaque blood-red filtrate.

Solution (C) may be subjected to a different treatment from the foregoing, and oxalic acid may be used to effect the separation. The solution is to be brought to the boiling point and oxalic acid added as long as effervescence is produced. The bichlorid of iridium is thereby reduced, the bichlorid of ruthenium and the sesquichlorid of rhodium are not affected. Salammoniac is then to be dissolved in the solution to thorough saturation. By standing and repose the double chlorid of rhodium and ammonium, $3NH_4Cl, Rh_2Cl_3+3HO$, separates out. The solution is then re-oxydized by boiling with aqua regia; by standing for some days in a cool place the iridium-salammoniac crystallizes out, and the supernatant solution contains double chlorid of ammonium and bichlorid of ruthenium which may be rendered pure by several recrystallizations.

For purifying the double chlorid of iridium and ammonium, $NH_4Cl, IrCl_2$, I give a decided preference to the method which I have described, with oxalic acid. It is simple and less trouble, and there is the further advantage that the platinum is left in the condition of double chlorid, whereas when the usual method of treating with aqueous sulphuretted hydrogen is used, the platinum is apt to be converted partly into sulphid, together with any traces of rhodium and ruthenium which may be present. When

oxalic acid is used, the platinum remains behind as a reddish powder, containing some iridium, from which it may be freed in the ordinary manner, if it is present in quantity sufficient to be worth working.

For treating a mixture such as that which I have here designated as (C) containing no platinum and ruthenium only as NH_4Cl, $RuCl_2$, it is unnecessary to apply reducing agents, and the first method which I have described is the best. But if it be proposed to effect the separation by the reduction of the iridium compound, the method which I describe in this paper, is preferable to that based on the use of sulphuretted hydrogen, even in this case.

The action of oxalic acid on the platinum metals is interesting. Its reducing effect upon bichlorid of iridium at the boiling point is immediate. On bichlorid of ruthenium it seems to have no effect whatever, may be boiled with it for a length of time without sensible result. In a trial made with sesquichlorid of ruthenium and ammonium the oxalic acid was boiled with the metallic salt for a considerable time without any apparent effect becoming visible, but by long-continued boiling a gradual precipitation took place. When platinum-salammoniac, NH_4Cl, $PtCl_2$, was boiled with oxalic acid, no effect was produced for a considerable time, but gradually the platinum salt diminished in quantity and the liquid acquired a stronger yellow color, perhaps owing to formation of soluble platinic oxalate. I was at first in hopes that the treatment with oxalic acid would have furnished a most easy and convenient method of purifying commercial platinum from the iridium always found in it. But the reduction of very small quantities of double bichlorid of iridium and ammonium in the presence of a large proportion of the corresponding platinum salt is difficult and slow, and the platinum salt itself is evidently attacked. It is for this reason that at the beginning of this paper I recommended in purifying iridium-salammoniac to use a sufficient quantity of water to hold all the iridium salt in solution at the boiling point, and to stop the operation as soon as the cessation of effervescence indicated that the action upon the iridium was terminated. The difference between the time of action of the oxalic acid on the two bichlorids is so very wide as to make it perfectly easy with proper care to effectually reduce the one without acting upon the other, except where the platinum is present in very large excess.

(II.)

The reactions of the alkalies on the chlorids of iridium are altogether peculiar. Upon the bichlorid they exert a reducing effect, converting it into sesquichlorid. An excess of alkali does

not precipitate the sesquioxyd, but seems to hold it in solution. On the application of heat the sesquioxyd gradually oxydizes itself at the expense of the atmosphere, and is then precipitated as deutoxyd of iridium. If to the cold solution containing excess of alkali, an acid be added, in small quantity, an impure sesquioxyd is precipitated in consequence of the neutralization of the alkali which held it in solution. But the sesquioxyd thus precipitated always contains a considerable quantity of the alkali used. It is very unstable, and by the action of the air is rapidly converted into blue oxyd. This is nearly all that we know of the sesquioxyd of iridium.

Under these circumstances it appeared to me desirable to investigate the action of some of the alkaline earths upon iridium solutions which it seemed possible, might throw a clearer light upon the relations of the sesquioxyd.

When a solution of caustic baryta is poured over iridium-sal-ammoniac, the iridium salt rapidly dissolves with a slight effervescence, the solution presently becomes comparatively decolorized, and a dark olive-green precipitate falls. This reaction, it will be observed, is completely different from that caused by potash.

The filtrate from this precipitate, which precipitate is but small in quantity, still contains a large quantity of iridium. If it be exposed to heat, as soon as it is moderately warm, its dark olive color changes almost suddenly to an Isabella color, it becomes cloudy, and an abundant precipitate falls, which in different experiments varies from pale grayish-yellow to yellowish-brown.

It was intended to submit both of these precipitates to a rigorous analysis. But the first was obtained in too small quantity, a few centigrams only. The second substance was much more abundant in quantity. A portion of it was prepared with great care, and with thorough exclusion of air, to prevent any admixture of carbonate of baryta. But upon careful examination, it was not sufficiently homogeneous in its composition to enable one to draw positive conclusions from an analysis, and the intention was therefore abandoned. The following were the properties observed.

The olive green precipitate seemed to be permanent in the air, and contained no baryta, or, at most, only traces. It dissolved in acids, leaving however a trace of black powder behind, and gave an olive colored solution, indicating that the iridium was in the condition of sesquioxyd.

The Isabella colored precipitate contained a considerable quantity of baryta. It dissolved in acids, and gave, when freshly prepared, also olive colored solutions. When dried at 212°, it was completely converted into an indigo colored mass, which dissolved in acids to an intense blue solution. When allowed to

dry at ordinary temperatures, even by exposure to the air, it was only oxydized in small part.

To observe the action of potash on this compound, a portion of the Isabella colored precipitate was placed in a watch glass, and a little caustic potash solution was poured over it. In a few minutes a blue tint was observable along the borders of the solution, and by exposure for a few hours the whole precipitate became intensely blue. We thus see that while potash is capable of reducing the bi-salts of iridium to sesqui-salts, its presence causes the sesquioxyd to take up oxygen from the atmosphere, with production of bioxyd. And that, for this action to take place, it is not necessary that the sesquioxyd should be in that anomalous state of solution in alkali, in which it seems to exist in solutions of bichlorid decolorized with excess of alkali; but that the barytic compound here described, which is comparatively permanent by itself, commences immediately to oxydize rapidly when placed in contact with potash.

Other reactions of platinum metals with baryta are as follows:

Sesquichlorid of ruthenium and ammonium is immediately and completely precipitated by baryta in the cold.

Bichlorid of ruthenium and ammonium gives no precipitate to the cold. Heated, it turns yellowish brown and becomes troubled. This troubling is completely removed by the addition of a large excess of the precipitant. If the baryta have been added to large excess at first, no troubling is occasioned by the application of heat.

Protochlorid of palladium is precipitated immediately in the cold by Ba. The brownish yellow precipitate does not redissolve in excess of the precipitant. In this the reaction of baryta differs from that of potash.

Bichlorid of platinum is scarcely affected by baryta water in the cold. Heat immediately produces a dirty white precipitate, the supernatant liquid remaining of a yellow color.

Sesquichlorid of rhodium gives an immediate light colored precipitate with baryta, which completely redissolves in a very large excess of the precipitant, even in the cold.

It will be seen from the foregoing that the reactions of baryta with the platinum metals differ widely from those produced by potash, and are highly characteristic.

Two of these solutions which much resemble each other, those of bichlorid of ruthenium and sesquichlorid of rhodium, are very well distinguished from each other by baryta, the former remaining for some time clear, the latter being instantly precipitated. The production of a well marked precipitate is generally a better test than a mere change of color, as produced by potash, which has hitherto been considered the best reagent to distinguish between these two substances.

The relations to color of the double sesquichlorid of iridium and ammonium, $3NHCl, Ir_2Cl_3 + 3HO$, are curious, and have not been exactly described. It is generally said that its solution is olive-green by reflected, and reddish by transmitted light. The following is a more correct description.

A dilute solution of the salt is always olive-green, whether seen by reflected or transmitted light. If it appears red by transmitted, when very dilute, this can only arise from the presence of bichlorid of ruthenium, or sesquichlorid of rhodium.

As its concentration increases, it gradually acquires a red color, visible by both reflected and transmitted light, but more conspicuous by the latter. A very strong solution is almost opaque to transmitted rays; by dilution, passes to a deep wine red. This wine-red solution is by reflected light olive-green, but with a distinct tinge of red. Nor has it before been remarked, I believe, that the crystallized salt exhibits the same dichroism. The crystals are deep green by reflected light, almost black. When placed so that light can strike through a dihedral angle, its color is ruby red.

Strong and weak solutions of this salt differ so much in color (in tint, not merely in intensity,) that at first one has a difficulty in believing that they contain one and the same substance.

New Ruthenium Reaction.—A series of experiments on the reactions of the platinum metals are as yet unfinished, but I take the present opportunity to mention a new and very beautiful reaction of the sesquichlorid of ruthenium.

When a solution of hyposulphite of soda is mixed with ammonia, and a few drops of solution of Ru_2Cl_3 are added, and the whole boiled, a magnificent red-purple liquid is produced, which, unless the solutions are very dilute, is black by transmitted light. The coloration is permanent, and the liquid may be exposed to the air without alteration.

This reaction is obtained with great ease and certainty, and will, I believe, be found far superior to any known test for ruthenium.

In order to determine the limits of the sensibility of this reagent, experiments were made with ruthenium solutions of different strengths. A portion of perfectly pure Ru_2Cl_3 was weighed out in a delicate balance, and the following indications were obtained:

With $\frac{1}{500}$ Ru_2Cl_3, bright rose purple.

With $\frac{1}{2000}$ and $\frac{1}{3000}$, fine rose-color.

With $\frac{1}{5000}$, paler, but still perfectly distinct.

With $\frac{1}{10000}$, the color, though very pale, was still unmistakably present.

Where the solutions are so very dilute as these last, the boiling must be continued for some minutes.[3]

Although the sulphocyanid test is very delicate, it is not equal to this, as was determined by a comparative trial. It is also liable to the objection that when employed to examine mixtures, the presence of iron might be confusing. For although the reaction of ferric salts with sulphocyanid gives a different shade of red, yet it is to be observed that the two colors approach each other considerably when much diluted. Moreover, in using the sulphocyanid test, I find it best to acidulate the liquid strongly with chlorhydric acid, and to obtain chlorhydric acid absolutely free from iron, so that it does not give the slightest coloration with the sulphocyanid; it is generally necessary (in this country, at least,) to prepare it for oneself.

The delicacy of this test does not however constitute its greatest value and superiority. The reactions of ruthenium are remarkably affected by the presence of iridium; and in proportion as this last named metal is present in larger quantity, the indications afforded by all the tests hitherto known grow less and less decided, and some lose all efficacy. The test here proposed is the first known reagent that is capable of detecting ruthenium in the presence of any excess of iridium. No precautions are necessary, and the reaction is always obtained with the greatest facility. The iridium solution is to be rendered alkaline with ammonia, a crystal of hyposulphite of soda is dropped into it, and the whole is boiled for two or three minutes. If no indication of a red-purple tint appears, (or, in case of small quantities of ruthenium, a rose color,) the iridium solution may be pronounced free from ruthenium.[4]

It would appear that there must exist very beautiful purple and green compounds of ruthenium, with which we are at present unacquainted. The purple compound appears to be produced in several reactions, and notably in that just described and in the sulphocyanid. There can be little doubt that sulphur enters into its composition. The green compound is produced when a solution of Ru_2Cl_3 is boiled with ferrocyanid of potassium. Claus remarks, in reference to this coloration, that he is unable to explain its cause. It is, however, unquestionably due to a compound of ruthenium, and not to the production of any

[3] When the presence of ruthenium in very small quantity, or in very dilute solution, is suspected, it is often advisable to boil the solution with a little chlorhydric acid, previous to the application of the hyposulphite, sulphocyanid, or other test. The explanation of this will be given in the second part of this paper. With the hyposulphite test the acidulated solution must be rendered alkaline by addition of ammonia before heating with hyposulphite.

[4] The second part of this paper will contain an examination of the reaction of hyposulphite of soda, and other reagents, upon the various metals of the platinum group.

prussian blue or green compound; for I find that the green reaction can be obtained in presence of a large excess of free ammonia, together with which, it is hardly necessary to remark, the last mentioned compounds could not exist. I propose to return to the subject of the ruthenium reactions at a future occasion.

Philadelphia, March, 1864.

(To be continued.)

ART. X.—*Contributions to Lithology;* by T. STERRY HUNT, M.A., F.R.S.; of the Geol. Survey of Canada.

PART III.—ON SOME ERUPTIVE ROCKS.

IN this Journal for March, 1860, ([2], xxix, 282) there is a short note, pointing out the existence, in the vicinity of Montreal, of several interesting classes of eruptive rocks, including quartziferous porphyries, trachytes, phonolite, dolerites, and diorites. It is proposed in the third part of the present paper to describe the results of some chemical and mineralogical examinations of these rocks, and to give, by way of preface, a description of their geographical distribution and geological relations. They may be considered geographically as belonging to two groups, of which the first and most important for the number and variety of its rocks may be conveniently described as the Montreal group. It consists of a succession of intrusive masses along a belt running nearly transverse to the undulations of the Notre Dame mountains, which are the prolongation of the Appalachians into eastern Canada. Commencing at Shefford mountain, an isolated trachytic mass not far removed from the western base of the Notre Dame range, we find, going westward, the detached hills known as Yamaska, Rougemont, Rouville or Belœil, Montarville or Boucherville, Mount Royal or Montreal, and Rigaud mountains; the last being distant about ninety miles from Shefford. Brome mountain, which occupies a large area to the south of Shefford, approaches within two miles of it. In like manner, a few miles to the south of Belœil is another intrusive mass known as Mount Johnson or Monnoir; making in all nine hills of eruptive rock belonging to the Montreal group. Beside these, numerous smaller intrusive masses in the form of dikes are met with around and between the hills. From Mount Royal to Rigaud mountain, a distance of about thirty miles, a gentle undulation of the strata is observed, which increases to the westward of Rigaud, and finally gives place to a considerable fault.

This disturbance has been traced to the Laurentide hills on the Lac des Chats, 140 miles west of Montreal; but to the eastward the strata exhibit no evidence of this transverse undulation, unless the appearance of the intrusive rocks already mentioned be supposed to indicate the prolongation of a fracture without sensible dislocation.

The whole of these eruptive rocks rise through unaltered paleozoic strata, which, however, in the immediate vicinity of the intrusive rocks, exhibit a local metamorphism. The hills of Shefford, Brome, and Yamaska break through the strata of the Quebec group, and lie a little to the east of the great line of dislocation which, in this region, brings up the lower members of the paleozoic series against the superior portion of the Lower Silurian, and divides into two districts the great paleozoic basin. (*Geology of Canada*, pp. 234, 597). The other hills all belong to the western division of this basin, and break through various members of the Lower Silurian series from the Potsdam to the Hudson River formation. Among the numerous dikes which traverse not only the sedimentary strata, but the intrusive masses, there are some which intersect the conglomerates of St. Helen's island; these are of uncertain age, but repose unconformably on the Lower Silurian series, and enclose pebbles and masses of Upper Silurian limestone characterized by fossils of the Lower Helderberg period. (*Ibid.*, p. 356.)

This group of intrusive rocks offers very great varieties in composition; thus Shefford and Brome consist of what we shall describe as a granitoid trachyte, while the succeeding mountain, Yamaska, and the most western, Rigaud, both consist in part of a kind of trachyte, and in part of diorite. Monnoir and Belœil also consist of diorites, which however differ from the last two, and from each other; while Rougemont, Montarville, and Mount Royal consist in great part of dolerites, presenting however many varieties in composition, and sometimes passing into pyroxenite. The dolerites of Rougemont and Mount Royal are cut by dikes of trachyte. Similar dikes also traverse the diorite of Yamaska, and may perhaps be connected with the trachytic portion of this mountain. It is probable, judging from some specimens from Rougemont, that the dolerite is there intersected by veins of diorite, some of which resemble that of Belœil, and others that of Monnoir. Dikes both of trachyte, phonolite, and dolerite are also found traversing the Lower Silurian strata in the vicinity of the great eruptive masses; and the conglomerate of St. Helen's mentioned above is traversed by dikes of dolerite, which in their turn are cut by others of trachyte.

A second and smaller group of intrusive rocks occurs to the northwest of Montreal, chiefly in the county of Grenville, where they traverse the gneiss and limestones of the Laurentian

system. The principal undulations of these rocks have, like those of the Appalachians, a north and south direction; but there is apparent also a second series of undulations, affecting in a less degree the geographical distribution of the strata, and having, like the Montreal and Rigaud undulation, an east and west direction. Coincident with the latter system of folds is a series of doleritic dikes, which no where attain a great breadth, but have in some cases been traced more than fifty miles in a nearly east and west direction. These dikes are interrupted by a great mass of reddish syenite, passing in some parts into granite, and occupying an area of about thirty-six square miles in the townships of Grenville, Chatham and Wentworth. Dikes of this syenite extend from the central mass, and traverse the surrounding gneiss and limestone. Numerous dikes of quartziferous porphyry intersect both this syenite and the surrounding gneiss, and are seen in one case to proceed from a considerable nucleus of porphyry, which rises into a small mountain; rendering it probable that numerous other porphyry dikes of the region radiate in like manner from other nuclei of the same rock. Some parts of this porphyry enclose fragments of syenite, dolerite, and gneiss, which vary in size from small grains to several feet in diameter, and often give to the rock the character of a breccia. In one instance a bed of gneiss, upwards of a hundred yards in length, is completely surrounded by the porphyry.

Orthophyre and Syenite.

Orthoclase-Porphyry or Orthophyre.—Under this head may be noticed a rock which has for its base a compact-petrosilex, or intimate mixture of orthoclase and quartz, rendered porphyritic by the presence of grains or crystals of orthoclase, of quartz, or of both of these minerals together. The occurrence of this rock at Grenville, where it forms dikes in the syenite of that region, has just been noticed. The fine-grained petrosiliceous base of this rock varies in color from dark green to various shades of red, purple, and black, these differences probably depending upon the degree of oxydation of the contained iron. Throughout this paste are disseminated well-defined crystals of a rose-red or flesh-red feldspar, apparently orthoclase, sometimes very abundant; and less frequently small grains of nearly colorless translucent quartz. An analysis was made of a characteristic variety of the rock, the base of which was greenish-black, jasper-like, conchoidal in fracture, and feebly translucent on the edges, with a somewhat waxy lustre. The hardness was nearly equal to that of quartz, and the specific gravity 2·62. A few distinct crystals of red orthoclase, and some grains of quartz, were present. The base, freed as much as possible from these, gave as follows:

	I.
Silica,	72·20
Aulmina,	12·50
Peroxyd of iron,	3·70
Lime,	·90
Potash,	3·88
Soda,	5·30
Volatile,	·60
	99·08

The oxygen ratio of the alkalies and alumina is 2·02 : 5·84, or nearly 1 : 3. The alumina requires 43·80 parts of silica to form with the alkalies 65·48 parts of a feldspar having the ratios 1 : 3 : 12, which are those of orthoclase and albite. There will then remain 28·4 parts of silica. This, with the exception of a small amount which is probably united with the oxyd of iron and lime, may be regarded as uncombined. The porphyries of this region receive a high polish, and are sometimes very beautiful.

Syenite.—The syenite of this region consists of orthoclase, usually flesh-red in color, and grayish vitreous quartz, with a small portion of blackish-green hornblende, which is sometimes almost or altogether wanting, and is occasionally accompanied with a little mica. The orthoclase is often nearly compact, but more generally distinctly crystalline and cleavable, and, so far as observed, is not associated with any triclinic feldspar. The hornblende is apparently subject to decomposition, becoming soft, earthy, and ferruginous in its aspect, while the feldspar retains its brilliancy. The partial analysis of such a specimen of the syenite gave only 0·56 of lime, and traces of magnesia, with 3·75 per cent of peroxyd of iron, and of alkalies, potash 4·43, soda 4·35. This large proportion of soda is also to be remarked in the orthophyre just described, and in the red orthoclase-gneiss of this region, a portion of which gave 3·86 per cent of potash and 3·70 of soda; while the red orthoclase from the rocks of this Laurentian series, named perthite by Dr. Thompson, gives in like manner 6·37 of potash to 5·56 of soda. A nearly pure potash-orthoclase, generally white in color, is however found in some of the stratified Laurentian rocks. (*Geology of Canada*, p. 474.)

This syenite of Grenville has in some portions undergone a peculiar decomposition, which has reduced it to a soft greenish matter having the aspect of serpentine, or rather of pyrallolite. This change has been remarked only in the vicinity of some remarkable veins of chert which are here found cutting the syenite, and as described by Sir W. E. Logan, is more or less complete for a distance of two hundred yards on each side of them. In specimens of this altered rock, the quartz remains unchanged; while the feldspar, still preserving its cleavages, has a hardness

no greater than carbonate of lime. It is somewhat unctuous to the touch, with a feeble waxy lustre, and its color is occasionally reddish, but more often of a pale green. Such a specimen was selected for analysis, and gave of silica 80·65, alumina 12·60, lime 0·60, soda and a little potash 2·65, volatile 2·10, magnesia and oxyd of iron, traces = 98·60. From this result it appears that the feldspar of the syenite has lost nearly two-thirds of its alkali; the iron and other bases having also for the most part disappeared. This removal of the protoxyd bases would appear, from the character of the resulting mineral, to be different from that which takes place during the kaolinization of feldspar. The nature of the process requires further investigation, but it was not improbably connected with the deposition of the adjacent chert or hornstone. This substance, according to Sir W. E. Logan, forms two large veins which cut the syenite vertically, and have a breadth of from four to seven feet. It is generally arranged in bands or layers parallel to the walls of the veins, and varying in color from white to yellowish and flesh-red. The mineral has the chemical characters of flint or buhrstone, and like the latter presents numerous irregular cells, the walls of which are sometimes incrusted with crystals of quartz, and in other cases bear the impression of small cubes, perhaps of crystals of fluorspar, which have themselves disappeared. The relations of these singular veins of silex show that it cannot be of sedimentary origin, and it can scarcely be doubted that it is an aqueous deposit, and results from a similar process to that which on a lesser scale gives rise to agate and chalcedony in various rocks. (*Geology of Canada*, p. 41.)

Trachytes.

Under this head we shall describe a class of rocks which are very abundant in Eastern Canada, and present a great variety of aspects. There are many dikes in the vicinity of Montreal which resemble some of the typical trachytic rocks of Auvergne and of the Rhine; while the rocks of the mountains of Brome and Shefford consist almost entirely of distinctly crystalline feldspar. These will be described as granitoid trachytes, under which head may also be included a somewhat similar rock from Yamaska mountain.

Brome and Shefford Mountains.—The trachytes of Brome and Shefford occupy two considerable areas near to each other, and, as already stated, are the easternmost of the eruptive masses now under description. The larger area covers about twenty square miles in Brome and the western part of the township of Shefford. It consists of several rounded hills, of which the principal are named Brome and Shefford mountains, and rise boldly about 1,000 feet above the surrounding plain. The rock shows divisional planes, giving it an aspect of stratification, and

separates by other joints into rectangular blocks. The second area includes about nine square miles in the township of Shefford, to the northwest of the last, and at the nearest point is only about two miles removed from it. This is known as Shefford mountain.

The rocks of these two mountainous areas present but very slight differences, being, so far as examined, everywhere made up in great part of a crystalline feldspar, with small portions of brownish-black mica, or of black hornblende, which are sometimes associated. The proportion of these two minerals is never above a few hundredths, and is often less than one hundredth. The other mineral species are small brilliant crystals of yellowish sphene, and others of magnetic iron, amounting together probably to one thousandth of the mass. In some finer-grained varieties a few rare crystals of sodalite and of nepheline are met with. But for the uniform absence of quartz, these rocks might be taken for varieties of granite and syenite. They are very friable, and subject to disintegration, so that the soil for some distance around these mountains is almost entirely made up of the separated crystals of feldspar, which however show but little tendency to decomposition, and retain their lustre. The rock is sometimes rather finely granular in its texture, but is often composed of cleavable masses of orthoclase, which are from one-fifth to one-half of an inch in breadth, and sometimes nearly an inch in length. The lustre is vitreous, and in the opaque varieties, pearly; but the crystals never exhibit the eminently glassy lustre nor the fissured appearance that characterizes the feldspars of many European trachytes which are similar to them in compotion. The color of the feldspar of these rocks is white, passing into reddish on the one hand, and into pearl-gray or lavender-gray on the other.

Specimens of the rock of Brome mountain were taken from the side near to the village of West Shefford. It was coarsely crystalline, lavender-gray in color, and contained a little brown mica, sphene, and magnetic iron, but no hornblende. The density of fragments of the rock was found to be 2·632–2·638. Selected grains of the feldspar had a specific gravity of 2·575, and gave by analysis the result II. The analysis of a second specimen from another portion of the hill, is given under III.

The rock from the south side of Shefford mountain was next examined. In one part it consisted of a coarse grained grayish-white feldspar with a little black mica, and closely resembled the rock just described from the adjacent mountain. A little lower down the hill, however, was a variety which, though completely crystalline, was more coherent and finer grained than that of Brome, the feldspar rarely exhibiting cleavage-planes more than a fourth of an inch in length. Brilliant crystalline

grains of black hornblende, about the size of grains of rice, were sparingly disseminated through the mass, together with very small portions of magnetite and yellowish sphene. Fragments of the rock had a density of 2·607–2·657. The feldspar was yellowish-white and sub-translucent, with a somewhat pearly lustre. By crushing and washing the mass, the grains of feldspar were separated from the heavier minerals, and found to have a specific gravity of 2·561. The results of its analysis, which scarcely differs from that of Brome, is given under IV.

	II.	III.	IV.
Silica,	65·70	65·30	65·15
Alumina,	20·80	20·70	20·55
Lime,	·84	·84	·73
Potash,	6·43	....	6·39
Soda,	6·52	....	6·67
Volatile,	·50	....	·50
	100·79		99·99

Yamaska mountain.—About twelve miles to the north of west from Shefford mountain rises the hill of intrusive rock known as Yamaska mountain, which has an area of about four square miles, and breaks through the strata of the Quebec group near the line of the great dislocation which brings these up against the limestones of the Trenton group. The southeastern part of this hill consists of a granitoid diorite hereafter to be noticed; but the greater portion of the mass may be described as a granitoid trachyte, differing in aspect from that of Brome and Shefford, in being somewhat more micaceous and more fissile. The mica, which is dark brown, is in elongated flakes, and there is neither hornblende nor quartz in the specimens collected, which however hold small portions of magnetite, and minute crystals of amber-yellow sphene. These seem to be contained in veins of segregation, which are of a lighter color than the mass. The cleavable feldspar grains, which make up by far the greater part of the rock, are brilliant, with a vitreous lustre, and are often yellowish or reddish-gray in color. A portion of this feldspar separated by washing from the crushed mass of the rock, had a specific gravity of 2·563, and gave by analysis the result V. Another portion of selected grains of the feldspar gave VI. Both specimens were however somewhat impure.

	V.	VI.
Silica,	61·10	58·60
Alumina,	20·10	21·60
Peroxyd of iron,	2·90	2·88
Lime,	3·65	5·40
Magnesia,	·79	1·84
Potash,	3·54	3·08
Soda,	5·93	5·51
Volatile,	·40	·80
	98·41	99·71

Besides these great trachytic hills, numerous smaller masses of different varieties of trachyte, in the form of dikes and beds, are found along the line of country between Rigaud and Yamaska mountains. The diorite of the latter is cut into dikes of a white or brownish-gray trachyte, which is often porphyritic, and may be connected with the great mass just described.

Chambly.—At Chambly a mass of porphyritic trachyte is intruded in the form of a bed among the strata of the Hudson River formation; and about midway on the Chambly canal a similar trachyte is met with, which contains in drusy cavities, crystals of quartz, calcite, analcime, and chabazite. The base of this rock is of a pale fawn color, and appears at the first sight to be micaceous; but on closer examination it is seen to be almost entirely feldspathic. Minute portions of pyrites, and grains of magnetic iron are rarely met with, and small scales of a dark green micaceous mineral are very sparsely disseminated. The crystals of orthoclase, which are very abundant, are sometimes an inch in length, and one-fourth of an inch in thickness; they are more or less modified, and terminated at both ends. They are easily detached from the rock, and are yellowish and opaque on the exterior, but the inner portions of the large crystals are transparent and vitreous. The composition of the crystals is given under VII. The paste of this porphyry, when carefully freed from crystals, lost by ignition 2·1 per cent. When pulverized and digested with dilute nitric acid, it effervesced slightly, giving off carbonic acid, together with red fumes, arising in part from the oxydation of the pyrites. The portion thus dissolved equalled carbonate of lime 1·76, carbonate of magnesia 0·98, peroxyd of iron with a trace of alumina 2·12 per cent. The residue dried at 300° F. gave the result VIII.

	VII.	VIII.
Silica,	66·15	67·60
Alumina,	19·75	18·30
Peroxyd of iron,	....	1·40
Lime,	·95	·45
Potash,	7·53	5·10
Soda,	5·19	5 85
Volatile,	·55	·25
	100·12	99·85

The paste of this trachyte thus differs but little from the crystals in composition. It contains only a slight excess of silica, and seems to be made up of lamellæ of orthoclase, mingled with small portions of carbonates of lime and magnesia. A part of the iron also is probably present as carbonate, which, by its decomposition, gives rise to the rusty red color of the weathered surface of the trachyte.

Montreal.—The island of Montreal offers a great variety of trachytic rocks, which traverse both the Lower Silurian strata, and the dolerite of Mount Royal. Some of these dikes are

finely granular, occasionally crumbling to sand, and frequently are earthy in texture. In some cases they assume a concretionary structure, and they are often porphyritic from the presence of feldspar or hornblende. One variety exhibits large feldspar crystals in a compact purplish or lavender-gray base, with a waxy lustre. This effervesces with acids from an admixture of earthy carbonates, and closely resembles in its aspect certain trachytes from the Siebengebirge on the Rhine. Other varieties can scarcely be distinguished from the so-called domite, the trachyte of the Puy de Dôme, and exhibit small drusy cavities. The presence of carbonates in trachytic rocks has generally been overlooked; Deville however found seven per cent of carbonate of lime in a trachytic rock from Hungary, and it occurs disseminated in some of the trachytes of the Siebengebirge. Some of the trachytes about to be described contain moreover carbonates of magnesia and protoxyd of iron, and weather to some depth of a reddish-brown color from the peroxydation of the latter, like the trachyte from Chambly just noticed. Acids remove from many of these rocks, in addition to the carbonates, portions of alumina and alkalies. These are derived from a soluble silicate, which in the trachytes of Brome appears only as rare crystals of nepheline, and in Chambly as analcime and chabazite. In some of the compact and earthy varieties about Montreal, however, this soluble silicate exists to a large extent, and has the composition of natrolite. By this admixture of a zeolite the trachytes pass into phonolite.

The first of these trachytes which will be noticed forms a dike near McGill College. The rock is divided by joints into irregular fragments, whose surfaces are often coated with thin bladed crystals of an aluminous mineral, apparently zeolitic. Small brilliant crystals of cubic iron-pyrites, often highly modified, are disseminated through the mass. The rock has the hardness of feldspar, and a specific gravity of from 2·617 to 2·632. Its color is white, passing into bluish and grayish-white; it has a feebly shining lustre, and is slightly translucent on the edges, with a compact or finely granular texture, and an uneven sub-conchoidal fracture. Before the blowpipe it fuses with intumescence into a white enamel. The rock in powder is attacked even by acetic acid, which removes 0·8 per cent of carbonate of lime, besides 1·5 per cent of alumina and oxyd of iron; the latter apparently derived from a carbonate. Nitric acid dissolves a little more lime, oxydizes the pyrites, and takes up, beside alumina and alkalies, a considerable portion of manganese. This apparently exists in the form of sulphuret, since, while it is soluble in dilute nitric acid, the white portions of the rock afford no trace of manganese before the blowpipe; although minute dark colored grains, associated with the pyrites, were found to give an intense

manganese reaction. From the residue after the action of the nitric acid, a solution of carbonate of soda removed a portion of silica; and the remainder, dried at 300° F., was free from iron and from manganese. Its analysis is given under IX, while that of the matter dissolved by nitric acid and carbonate of soda from 100 parts of the rock will be found under IX *a*.

A dike of trachyte near to the last, and very similar to it in appearance, was submitted to the action of nitric acid, but the insoluble residue was not treated by carbonate of soda. Its analysis is given under X, while that of the soluble matters is to be found under X *a*. A white trachyte from a dike at Lachine resembled the preceding, but was somewhat earthy in its aspect, and effervesced with nitric acid, which removed a portion of lime equal to 7·40 per cent of carbonate. On boiling the pulverized rock with nitrate of ammonia, an amount of lime equal to 5·33 per cent of carbonate was dissolved. An accident prevented the complete determination of the alkalies in the feldspathic residue of this trachyte; and the soluble silica was not removed previous to the analysis, whose result is given under XI. The proportion of the potash to the soda was however found to be, by weight, nearly as two to three. The matters dissolved by nitric acid will be found under XI *a*.

Another dike of trachyte from Lachine was concretionary, and stained by infiltration; the interior of the concretions was white and earthy. The substances removed from 100 parts of the rock by nitric acid and carbonate of soda, are given under B. A partial analysis of the insoluble residue showed it to be a feldspar allied to those of the preceding trachytes; the quantities of potash and soda were however nearly in the ratio of four to three.

A large dike of trachyte in the limestone quarries at the Mile End, near Montreal, is remarkable for the amount of carbonates which it contains. It is grayish-white, with dark gray spots, granular, sub-vitreous in lustre, and holds a few crystals of hornblende. By ignition it loses 11·0 per cent of its weight. In powder it effervesces freely with nitric acid, disengaging carbonic acid, and, when heat is applied, red fumes from the peroxydation of the iron. One hundred parts of the rock yielded in this way the soluble matters given under XII *a*. The composition of the residue, from which the soluble silica was not removed, is given under XII.

	IX.	X.	XI.	XII.
Silica,	63·25	62·90	58·50	61·62
Alumina,	22·12	23·10	24·90	21·00
Lime,	·56	·45	·45	2·69
Potash,	5·92	2·43	....	4·66
Soda,	6·29	8·69	....	5·35
Volatile,	·93	1·40	2·10	2·37
	99·07	98·97		97·69

A second determination of the alkalies in a portion of the trachyte, IX, which had not previously been treated by acid, gave potash 5·40, and soda 6·49. A second analysis of X. gave potash 2·28, and soda 7·95.

	IX *a.*	X *a.*	XI *a.*	*b.*	XII *a.*
Silica,	1·43	....	....	5·00	....
Alumina,	2·43	....	1·27	1·32	4·84
Peroxyd of iron,	2·40	2·84	1·47	2·51	2·63
Lime,	·60	1·86	4·14	3·50	6·49
Magnesia,	....	....	1·34	1·35	1·70
Potash,	·40	·25	undet.	undet.	undet.
Soda,	·98	·21	"	"	"
Red oxyd of manganese,	1·31	·87	....	....	....

Of the matters soluble in nitric acid in the last-described trachyte, XII, the lime in the form of carbonate would equal not less than 11·60 per cent, the magnesia 3·58, and the iron 3·82 per cent of carbonate, in which condition by far the greater part of these bases are probably present.

Phonolite.

Associated with the numerous trachytic dikes at Lachine is one of the phonolite already referred to. It is brittle and somewhat schistose, breaking into angular fragments, and appears to consist of a reddish fawn-colored base, in which are disseminated greenish-white rounded masses, often grouped, and apparently concretionary in their structure. These greenish portions are sometimes half an inch or more in diameter, and cover from one-third to one-half of the surfaces. They are not very distinctly seen unless the rock is moistened. The hardness of the different portions does not greatly vary, and is nearly that of apatite. The specific gravity is very low, being only 2·414. The mass contains small cavities filled with carbonate of lime, which is rarely stained purple: it is also found in small films in the joints. The rock is granular in its fracture, without lustre, and is feebly translucent at the edges. When pulverized, and treated with nitric acid of specific gravity 1·25, a slight effervescence ensues, with abundant red fumes. The mass grows warm and gelatinizes; and on washing out the acid solution, and treating the insoluble portion with a solution of caustic soda, a white granular residue remains. These reactions are obtained both with the fawn-colored and the greenish portions, but the amount of insoluble matter is greater from the last. The rock is but slightly hygroscopic: a portion of it in powder lost only 0·2 per cent by a prolonged exposure to 212° F., but 7·10 per cent at a red heat.

For the quantitative analysis, the method already indicated was followed. It was found that while a dilute solution of caustic soda removed all of the gelatinous silica separated by the acid, it took up only a trace of alumina; leaving a feldspathic

residue which was no longer attacked by nitric acid. The silica was separated from the alkaline liquid, and the acid solution was found to contain, beside alumina and soda, a little potash, some lime, magnesia, and iron, and traces of manganese. The greater part of the lime is evidently present as carbonate; for when a portion of the pulverized phonolite, which gave to nitric acid lime equal to 4·36 per cent of carbonate, was boiled with a solution of nitrate of ammonia, there were dissolved 3·87 per cent of carbonate of lime, beside which there was a separation of a considerable amount of oxyd from the decomposed carbonate of iron. From this reaction, and from the entire absence of sulphur, which was carefully sought for, it is probable that the whole of the iron, except the small portion of peroxyd which colors the rock, exists in the state of carbonate. In the following analyses, therefore, the lime and the iron, as well as a little magnesia, are calculated as carbonates. XIII. is the result obtained with four grams of the reddish portion of the phonolite, as free as possible from the green; and XIV. was obtained with two and a half grams of a mixture of the two colors.

	XIII.	XIV.
Soluble silicate, zeolite (*a*), by difference,	46·57	36·16
Insoluble silicate, feldspar (*b*),	45·75	55·40
Carbonate of lime,	3·63	4·36
" iron,	3·52	3·72
" magnesia,	·53	·36
	100·00	100·00

In order to fix the composition of the soluble silicate, the larger amount of the insoluble residue and that of the separated silica, alumina, and alkalies, having been carefully determined, and the lime, magnesia, and oxyd of iron calculated as carbonates, the water was estimated by the loss. In this way were obtained the results given under XIII *a*, and XIV *a*; while the analyses of the insoluble silicate, which is a potash feldspar, are given under XIII *b*, and XIV *b*.

	XIII *a*.	XIV *a*.	Natrolite.	Analcime.
Silica,	51·96	51·66	47·40	54·06
Alumina,	24·42	24·88	26·09	23·20
Soda,	12·93	13·05	16·02	14·10
Potash,	1·15	1·28	....	....
Water,	9·54	9·13	9·05	8·10
	100·00	100·00	100·00	100·00

In composition, this zeolitic mineral is intermediate between analcime and natrolite; but the readiness with which it gelatinizes with acids leads to the conclusion that it belongs, in great part at least, to natrolite. The theoretical composition of these two zeolites is, for the sake of comparison, placed alongside of the two analyses of the soluble portion of the phonolite.

	XIII *b*.	XIV *b*.
Silica,	59·70	60 90
Alumina,	23 25	24 45
Lime,	·99	·45
Potash,	9·16	undet.
Soda,	2·97	"
Volatile,	2 23	2·10
	98·30	

The feldspars of the above trachytes and phonolite offer some considerable variations in their composition, especially in the proportions of the alkalies. In IX, the proportions of potash and soda are nearly the same as in the trachytes of Brome, Shefford, and Chambly, and the same is true of XII. These are doubtless to be regarded as varieties of orthoclase with a large amount of soda, while in the feldspar from the phonolite the proportion of soda is very small. In X, on the contrary, the large predominance of soda indicates a composition approaching that of albite. It is further apparent, from a comparison of the feldspars of the other trachytes whose complete analyses are not given, that the proportions of the alkalies are liable to considerable variation, even in adjacent and apparently similar dikes. All of the above feldspars are probably to be referred to orthoclase, or to albite; but these, in the earthy trachytes, have undergone a commencement of decomposition, which consists in the loss of a portion of silica and alkali, and the combination of water, resulting in the formation of kaolin. An admixture of this substance will explain the increased amount of alumina, the deficiency of silica, and the presence of water in the feldspars of the more earthy of these trachytes.

These trachytic dikes are not confined to the vicinity of Montreal. To the southward, on the shores of Lake Champlain, there is found in and about Burlington, Vermont, a vast number of dikes of intrusive rock; some of which appear to intersect the strata of the Quebec group, and others those of the Trenton group. Some of these are described as being of greenstone; and others, as a white or yellowish-white feldspathic rock, often porphyritic from the presence of feldspar crystals. The base of a yellowish-gray porphyritic dike from Shelburne, having a rough fracture, and a specific gravity of 2·60, gave to Prof. G. F. Barker, silica 67·30, alumina and peroxyd of iron 19·10, lime 0·79, magnesia, traces, potash 4·74, soda 6 04, volatile 1·70 = 99·67. It contained a little intermingled quartz; and the mass resulting from the fusion of the rock with an alkaline carbonate, afforded traces of a sulphuret. (*Geology of Vermont*, pp. 579–707.)

Somewhat to the south of Burlington, on the west side of Lake Champlain, and near to Essex, there is a great mass of intrusive rock, found in the slates of the Hudson River formation. As described by Emmons, it is interstratified in an irregular manner among the layers of the unaltered sedimentary rocks,

and has a fissile and schistose structure, which gives, at first sight, the aspect of stratification to what is undoubtedly an intrusive rock. When exposed to the action of the waves on the lake-shore, its structure appears to be columnar, and sometimes concretionary. This rock is described as composed of a reddish or pale leek-green compact feldspar, holding crystals of the same mineral. (*Geology of New York*, vol. ii, p. 84.) These intrusive feldspathic rocks on Lake Champlain resemble closely the trachytes of Montreal and Chambly,—with the latter of which, the trachyte of Shelburne, the only one of them which has been chemically examined, closely agrees in composition.

[To be continued.]

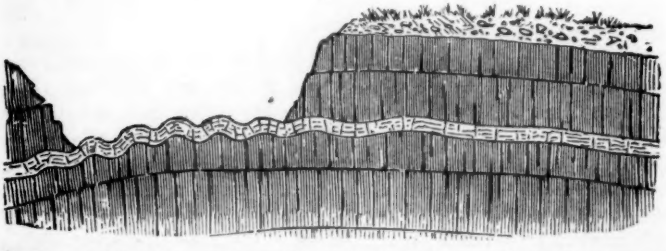
ART. XI.—*On the so-called "Barrel-Quartz," of Nova Scotia;* by B. SILLIMAN, Jr.[1]

ON Laidlaw's Hill, forming the eastern division of the Waverley Gold District, has been found, in great abundance, a peculiar variety of quartz-rock which has acquired a wide reputation under the name of *barrel-quartz.*

Mr. Phillips, of London, has thus described it:

"The most remarkable deposit of auriferous quartz hitherto found in Nova Scotia is undoubtedly that at Laidlaw's Farm. The principal workings are here situated near the summit of a hill composed of hard, metamorphic shales, where openings have been made, to the depth of four or five feet, upon a nearly horizontal bed of corrugated quartz of from eight to ten inches in thickness. This auriferous deposit is entirely different from anything I had before seen, and when laid open presents the appearance of trees or logs of wood laid together side by side, after the manner of an American corduroy road.

1.



"From this circumstance the miners have applied the name of 'barrel-quartz' to the formation, which, in many cases, presents

[1] From a Report by B. SILLIMAN, Jr., on the Waverley Gold Mining Co., Boston, 1864.

an appearance not unlike a series of small casks laid together side by side and end to end.

"The rock covering this remarkable horizontal vein is exceedingly hard; but beneath it, for some little distance, it is softer and more fissile. The quartz is itself foliated parallel to the lines of curvature, and exhibits a tendency to break in accordance with these striæ.

"The headings, and particularly the upper surfaces of the corrugations, are generally covered by a thin bark-like coating of brown oxyd of iron, which is seen frequently to enclose numerous particles of coarse gold, and the quartz in the vicinity of this oxyd of iron is itself often highly auriferous."

The accompanying section, (fig. 1) which I have prepared from a sketch of the place as I saw it in December, will, together with the following perspective view of the opening, convey a clear idea of its peculiar structure.

2.

Only the corrugations in the open part of the cut are visible; the extension of the vein to the right and left, in fig. 1, is ideal, the superincumbent mass covering it. I measured, however, the quartzite above, dipping to the right and left at a small angle, and I think no geologist would doubt that the crest of an anticlinal axis here comes to the surface and has escaped the denudation which has removed the top of the crest in most places. The corrugations, or folds, appear to be accounted for on the hypothesis of a lateral thrust producing the undulations. The perspective view (fig. 2) of this interesting locality was taken from a stereoscopic photograph, showing the appearance of the barrel-quartz after the surface-rock (quartzite) had been removed, and before the miners had broken up the quartz layer for removal.

The value of the barrel-quartz has been not so much from its large average yield of gold as from the comparative cheapness with which it has been mined. Thus it appears from the statements in the Chief Gold Commissioner's Report, dated Jan., 1863, that each miner on Laidlaw's Farm averaged for the last three months of the previous year over nine tons per month, while in other districts the average monthly product per man was from two to three tons. The average yield of gold was small,—about five pennyweights to the ton; the maximum being three ounces, not including remarkable discoveries, like that of the Chebucto Company, of a mass of this quartz, yielding, as already mentioned in the Introduction, for a volume of not over two cubic feet, over $4000 in value, of gold.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS AND CHEMISTRY.

1. *On the constitution of the Sun.*—MAGNUS has communicated a brief note in which he endeavors to show that purely thermic relations permit us to draw important inferences as to the physical character of the sun. If we observe the quantity of heat which is radiated from a non-luminous gas flame and then introduce soda into the flame, the quantity of heat radiated will be increased. The experiment was made in such a manner that a definite portion of the soda flame was constantly compared with the same part of the non-luminous flame, but so that the soda introduced into the flame could not radiate directly toward the thermo-electric pile. Although the temperature of the flame was lowered by the introduction of the soda, yet one-third more heat was radiated. When a plate of platinum was introduced into the flame instead of the soda, the quantity of heat radiated was much greater than before, although the plate absorbed more heat from the flame than the soda. With the plate of platinum employed, which was 55 millimetres broad, the amount of heat radiated was nearly twice as great as that of

the non-luminous flame. Variations in the thickness of the plates of platinum employed made no sensible difference in the heat radiated, provided that the plates had the same diameter. When the plate of platinum was covered with carbonate of soda, the radiation increased in a remarkable degree, being one-half greater than that of the plate alone. The quantity of heat radiated was still further increased when, in addition to the covered platinum plate, the flame contained soda vapor arising from a little soda placed below the plate in the flame and not itself radiating heat to the pile. Under these circumstances the covered plate radiated nearly three times as much heat as the flame alone. Salts of strontium and lithium behaved like salts of sodium. These experiments show that gaseous bodies radiate very much less heat than solids or liquids, and that consequently it can scarcely be assumed, that the gaseous photosphere of the sun is the source of the sun's heat. They show also that ignited soda at the same temperature has a much higher radiating power than ignited platinum. Finally, they prove that soda vapors absorb very little of the heat which is radiated by the solid or fluid ignited body, for the radiation of the solid body in the flame filled with the vapor of soda was but little less than the sum of the radiation of the solid alone and the vapor alone. This behavior of ignited soda in the fluid and gaseous condition, confirms the views of Kirchhoff on the constitution of the sun in a very striking manner.—*Pogg. Ann.*, cxxi, 510. W. G.

2. *On the Spectrum of Thallium.*—W. A. Miller has found that when pieces of thallium are made to form the electrodes of an induction coil, the spark exhibits in the spectroscope five new lines in addition to the well known characteristic green line. The new lines are a very feeble line in the orange, two almost equally intense in the green and more refrangible than Tlα, a third and weaker line in the green, and finally a bright sharp line in the blue. All these lines could be observed in an atmosphere of hydrogen, excepting the weakest, but they were in this case less intense. The photographed thallium spectrum exhibits a very characteristic group of lines resembling the spectra of cadmium and zinc, and somewhat less that of lead.—*Phil. Mag.*, xxvi, 223. W. G.

3. *On the photographic transparency of various bodies, and on the photographic effects of metallic and other spectra obtained by means of the electric spark.*—W. A. Miller has published an interesting paper upon photographic transparency and kindred subjects, from which we extract the principal results only, referring for details to the original memoir. The author employed prisms, lenses, and plates of rock crystal to avoid the effect of absorption due to the use of glass. It was found that—

(1.) Colorless bodies which possess equal powers of transmitting the luminous rays vary greatly in permeability to the chemical rays.

(2) Diactinic solids (that is to say, solids which are permeable to the chemical rays) preserve their diactinic power both when liquefied and when converted into vapor.

(3.) Colorless solids which are transparent to light, but which exert a considerable absorptive effect upon the chemical rays, preserve their absorptive power with greater or less intensity both in the liquid and the gaseous state.

These conclusions are equally true as regards liquids, whether the

compound be dissolved in water or liquefied by heat. Water is perfectly permeable to the chemical rays, and the process of solution does not interfere with the special action of the substance dissolved upon the incident rays. This fact makes it possible to submit to examination a great variety of saline bodies which cannot be obtained in large or limpid plates. Of the substances examined by the author no one was found to surpass rock crystal in diactinic power. Water, ice and white fluor spar rival it, and pure rock salt approaches it very closely. With respect to saline bodies, it was found that the *fluorids* rank first in diactinic power; then follow in order the chlorids, bromids, and iodids. The sulphates, carbonates, and borates of the alkalies and earths are largely diactinic, the phosphates less so, and the arseniates still less. The sulphites are less diactinic than the sulphates, and the hyposulphites less than the sulphites. Nitric acid and the nitrates exert a specific absorptive action, interrupting the spectrum abruptly at the same point whatever be the base, provided that this be capable of forming diactinic salts. Among bases, potash, soda, ammonia, lime, baryta, strontia, magnesia and alumina are eminently diactinic. The oxyds of zinc, mercury and lead approach them in power; but colored bases, like the oxyds of iron, nickel, cobalt and copper are very inferior, and when the salts formed are green or yellow, they are nearly opaque. Notwithstanding the high diactinic quality of silica, none of the different varieties of glass transmit rays extending beyond one-fifth or one-sixth of the range afforded by quartz. A plate of glass less than $\frac{1}{100}$th of an inch in thickness cuts off the more refrangible rays almost as completely as a plate of twenty times the thickness. Of the liquids examined, water is most diactinic, and next in order alcohol. Among gases, air, hydrogen, carbonic acid, carbonic oxyd and ammonia are about equally diactinic with each other and with water. Other gases and vapors exhibit a marked absorptive power, and this is especially the case with the compounds of sulphur. Chlorine, bromine and iodine absorb most powerfully the least refrangible rays, which is an exception to the general rule; peroxyd of nitrogen and peroxyd of chlorine in a stratum two feet in length wholly absorb the chemical rays; but when more dilute or in shorter columns, they give peculiar absorption bands. Aqueous vapor is highly diactinic, though not diathermic.

The reflecting power of different polished surfaces for the chemical rays was found to be very different for different substances, for the same angle of reflection. Gold reflects all the rays very equally, though somewhat feebly, and next to gold ranks burnished lead. These two metals reflect all the light of the silver-spectrum, or 74 divisions of the author's scale, while with other metals the reflected spectrum covered only 63 divisions of the same scale. In examining the electric spectra of different metals taken in air, the author found that as we advance toward the more refrangible end of the spectrum, the lines become less intense in the central portions; until toward the extreme limit the two marginal ends alone are visible, so as to give the appearance of two dots of color separated by a dark space. This appears to be due to the less intensity of the electric spark in the centre. The "dots" may usually be seen to consist of groups of very short lines closely aggregated. The spectra of

alloys usually exhibit the lines characteristic of each constituent, but this is not the case when one constituent is present in comparatively very small quantity. Thus plumbago, containing 3·94 per cent of iron, gave a distinct iron-spectrum, but no indication of iron was observable in the spectrum of brass containing 0·23 per cent of iron, or of lead in brass containing 0·7 per cent of this metal. The examination of the photographic effects of electric spectra produced by transmitting the spark through gases other than air, led to the following conclusions, which correspond with those of Angström, Alter, and Plücker.

(1.) Each gas tinges the spark of a characteristic color; but no judgment can be formed from this color of the kind of spectrum which the gas will furnish.

(2.) In most cases, in addition to the lines peculiar to the metal used as electrodes, new and special lines characteristic of the gas, if elementary, or of its constituents, if compound, are produced. When compound gases are employed, the special lines produced are not due to the compound as a whole, but to its constituents.

(3.) The lines due to the gaseous medium are continuous, not interrupted or broken into dots.—*Journal of Chemical Society*, [2], xi, 59.

W. G.

4. *On the spectrum of chloro-chromic acid.*—Gottschalk and Drechsel have observed that the vapor of chloro-chromic acid, CrO_2Cl, produces a spectrum containing 17 characteristic rays, of which 3 are violet, 8 green, 1 yellow, 3 orange, and 2 red. The most brilliant are the violet and one of the green. When the vapor is mixed with oxygen previously to its introduction into the flame, we obtain a spectrum of a brilliancy which the eye can scarcely support; the violet rays appear with peculiar brightness, and might be confounded with those of rubidium, though in reality they are somewhat less refrangible than these. Neither chlorine nor chlorid of chromium alone in the flame produce characteristic rays, so that the observed rays are due exclusively to the chlorid of chromium. —*Bull. de la Soc. Chimique de Paris*, Jan., 1864, p. 20. W. G.

5. *On the condensation of vapors upon the surface of solid bodies.*—Magnus has observed that a thermo-electric pile becomes warmer when brought into contact with moist air which has the same temperature as the pile, and becomes colder whey dry air of the same temperature passes over it. This phenomenon may be explained by the assumption that the surface of the pile absorbs aqueous vapor from the atmosphere, and thus becomes warmer by the latent heat which becomes sensible; and that the dry air again takes up the vapor from this surface, which becomes colder by evaporation. This holds good not only for surfaces covered with lampblack, but, which is very remarkable, even for clean metallic surfaces. Thus, thin platinum foil laid upon the face of the pile became warmer or colder according as moist or dry air was passed over it, and the same was true for plates of other metals. Finally, the results of a very careful series of experiments justify the generalization that all substances whatever become warmer when air containing more moisture than that which surrounds them impinges upon them, and colder when they are brought in contact with air containing less moisture than that in which they are placed. It further appears from the experiments of

Magnus that the most different vapors are condensed upon the surfaces of solid bodies to such a degree that appreciable changes of temperature result. Hence it follows that at all times a layer of condensed vapors exists upon the surfaces of bodies, which becomes greater or less with the state of moisture of the atmosphere.—*Pogg. Ann.*, cxxi, 174. W. G.

6. *On the influence of condensation in experiments on diathermancy.*—MAGNUS, in a brief reply to Tyndall's criticism on his previous remarks upon the influence of the condensation of moisture upon the thermo-electric pile, maintains without reservation the position which he at first held, namely, that air containing moisture permits the passage of rays of heat with almost the same facility as dry air.—*Pogg. Ann.*, cxxi, 186. W. G.

7. *Mr. Scoutetten on the electricity of the blood.*—At a recent meeting of the Paris Academy, Dr. Scoutetten returned to the important question of the electricity of the blood, and gave a historical sketch of the observations which have been made in the endeavor to prove, by an experiment which leaves no room for doubt, the electricity of the blood, and so arrive at the measurement of its electro-motive force. A large vase of porcelain, with a wide opening and capable of holding a litre and a half, was half filled with venous blood; in the midst of this was placed a porous vessel containing four hundred grams of arterial blood; two other small porous vases, of a capacity of sixty cubic centimetres, contained a solution of sulphate of zinc; these two vases were placed at the same time in the two sorts of blood. The zinc electrodes were placed in the solutions and did not touch the blood. As soon as the electrodes, which were previously attached to the galvanometer by brass wires, were inserted in the liquid, the current was established. The experiments were made on the 29th of October in presence of chemists, physicists, and other distinguished men of science. The blood was taken from a very old horse, in good health, which was to be slaughtered in the course of the day. The arterial blood came from the right carotid at the same time that the venous blood was taken from the left jugular vein; the porous vessel containing the arterial blood was then placed in the venous blood, and the whole apparatus surrounded by water at a temperature of 40° C., in order to prevent coagulation. The small porous vessels containing the solution of sulphate of zinc were sunk up to two-thirds of their height in the two sorts of blood. The amalgamated zinc electrodes were inserted lightly and simultaneously; the current manifested itself by the deviation of the needle; it indicated, as in the first experiments of Mr. Scoutetten, that the positive current travelled from the arterial to the venous blood across the galvanometer. After having reached the stop, the needle oscillated and became fixed at 66 degs., where it remained for an hour. The galvanometer employed was Nobili's, with a coil of 10,000 turns. To measure the electromotive force of blood, Mr. Scoutetten has had recourse, in this second series of experiments, to the method of opposition proposed by Poggendorff and so ably carried out by Mr. Jules Regnauld. On placing the coupling wire of the two small porous vases in opposition to a normal wire at a constant current, he saw at first that the current became reversed; and hence he concluded that the force produced by the reaction of the two sorts of blood is com-

prised between zero and 4·50. Proceeding thence to more exact results, he arrived at last at the conclusion that the electro-motive force sought was 1·82; that of Daniel's battery being 58; 100 representing the electro-motive power of pure zinc.—*Reader*, *May* 7, 1864.

8. *Note on Binocular Vision.*—The application of binocular vision to the microscope has been considered justly as the greatest improvement since the introduction of the achromatic objective. Mr. Wenham's single prism seemed to leave little further to be accomplished, the instrument being theoretically as perfect as could be devised, and, practically, giving great satisfaction. Mr. Tolles, of Canistota, N. Y., long favorably known by the great excellence of his objectives for the microscope and telescope, has advanced one step further, and, as it appears to me, in the only right direction to give complete satisfaction. I have lately received from him a *binocular eye-piece*, which is, as far as I can at present judge, every way superior to Mr. Wenham's ingenious arrangement.

In comparing them, I do not wish to be understood as at all depreciating Mr. Wenham's invention, so freely made public, and undoubtedly the best hitherto devised. The only instrument of this form I have had an opportunity of examining was a first class one by Smith, Beck & Beck, and it was certainly an excellent microscope. Yet, with no higher objective than the $\frac{2}{3}$ds in., there was a marked difference in the definition by reflected and direct vision; how far this was accidental I am unable to say, as I had no opportunity to examine the prism. The slanting tube, attached to one side, appeared to me awkward, and the reflected ray had to travel a longer path than the direct one; moreover, the use of a draw-tube for micrometry had to be dispensed with, as no longer length of draw-tube could be allowed than sufficient to adjust for different distances of the eyes of observers. Perhaps this is not a very serious objection; yet it is an objection. The binocular eye-piece meets all these difficulties. The division of the pencil is effected so far from the objective that the interference with definition is a minimum. I can clearly see the fine lines of *Hyalodiscus subtilis* and *Grammatophora subtilissima* with the $\frac{1}{10}$th in. objective, and the fine endings of the wedge-shaped markings on Podura are neatly shown with the $\frac{1}{5}$th and higher powers. The tubes are symmetrical and parallel, and are adjusted for different eyes by a screw and milled head, giving a range much greater than can ever be required; they slide upon a dove-tail hollow bar, and are always parallel with each other and the main tube.

No alteration is required for the adaptation of the eye-piece to any microscope, as it is used in precisely the same manner as the ordinary eye-piece; it lengthens the microscope, however, about four inches, though not necessarily so much.

The eye-piece, with its present arrangement, is a first class erecting one, giving, with the various powers up to the $\frac{4}{10}$ths, full and clear fields beautifully illuminated by the mirror alone, and without any special trouble with the higher powers, as is the case with Mr. Wenham's arrangement. Some care and special apparatus are required to bring out the full effect, and equally illuminate both fields. I have found that the ordinary achromatic condenser, stopping out the central rays and using the plain side of the reflector, or better a reflecting prism, and the bull's-eye condenser,

to work very well; and with this arrangement have had fine views of the test objects with the $\frac{1}{5}$th and $\frac{1}{10}$th in. objectives. Some facts as to the structure of certain of the Diatoms, have been brought out with wonderful distinctness; there is a rotundity and solidity which gives a more complete idea of the structure of such forms as *Aulacodiscus Petersii*, and the *Amphiproræ*, than can be had by monocular vision. These effects, however, are not to be had but by careful manipulation, and there is yet needed some means of more ready equable illumination with the higher powers, and Mr. Tolles is now attending to this. An experienced microscopist would, however, succeed in bringing out very satisfactory effects with the means at present employed.

With the lower powers, 3 in. to $\frac{2}{3}$ds in. or $\frac{4}{10}$ths in., nothing can exceed the beauty and brilliancy of objects seen for the first time with binocular vision. The transparent injections (German) sold by Smith, Beck & Beck are exceedingly beautiful. Upon some of these I compared the Wenham binocular and Mr. Tolles's eye-piece. It is with opaque objects that the finest effect is produced, without any special care in illumination. When both eyes are employed there is greater depth of vision, or capability in the eyes—the top and bottom of tolerably thick preparations being seen together, or, at least, much better than when one eye alone is employed. At the same time, the stereoscopic effect is wonderful: the field of view appears suddenly enlarged and comprehensive, and the magnifying power increased, and the relief to the eyes is very great.

The living Diatomaceæ and Desmidiæ are shown with great effect with a good $\frac{4}{10}$ths or $\frac{1}{5}$th objective. They appear floating at different depths in a vast ocean, and with so little loss in definition that the ciliæ of *Closterium Lunula* are readily observed, as also those of the monads and larger animalcules, which appear like monsters in a vast deep.

I am not at liberty at present to explain the principle upon which Mr. Tolles has been enabled to divide the pencil so far from the objective; it is theoretically, as well as practically, correct, and it appears a little strange that so obvious a principle did not at once occur to those eminent European opticians who have devoted so much time and skill to the perfection of binocular arrangements for the microscope. That the present form is the ultimatum, neither Mr. Tolles nor myself anticipates, although it is at present quite perfect and gives me great satisfaction.

The power of the eye-piece is variable in the same manner as with Wenham's binocular. No alteration is required for polarization experiments, but the prism is inserted in precisely the same place and manner as with the single eye-piece. In fact, the old arrangements of the microscope are left untouched, the whole effect of binocular vision being produced in the eye-piece.

The use of the binocular eye-piece at once tests the quality of the objective, as none but perfectly corrected glasses will give satisfaction; when the two images are formed by halves of the objective, and calling into play especially the extreme portions, none but objectives of large angle and first quality will stand the test; and this is the more necessary with the high powers, since, in order to obtain sharp, clear vision, the central pencil should be stopped out, and the object illuminated by oblique light. The condenser Mr. Tolles is now at work upon will, I hope, render the

use of the binocular comparatively as easy, with the higher powers, in the hands of a novice, as now it is with the lower powers under the management of an experienced microscopist.

The eye-piece works very well when applied to the telescope, but the stereoscopic effect is not equal to that produced when applied to the microscope, owing to the small angle of the object-glass. I have had very fine views of Saturn and the moon with it; there is some slight loss of light, not perceptible when looking at land objects, but noticeable upon such faint objects as the nearer satellites of Saturn.

The difficulties of illumination with the higher powers of the microscope are only with transparent objects; with opaque objects there is no trouble; and as the condenser of Mr. Tolles' will no doubt remove this difficulty, the binocular eye-piece should become a part of every well equipped microscope. H. L. S.

9. *On the isomorphism of silica with deutoxyd of manganese.*—G. ROSE has directed attention to the constitution of the two minerals Braunite and Marceline, and has shown that in order to explain their isomorphism it is necessary to admit that SiO_2 is, in combination at least, isomorphous with MnO_2. Thus, we have

$$\text{Braunite, } \left.\begin{matrix}\dot{Mn}\\ \dot{Ba}\end{matrix}\right\}\ddot{Mn} = \dot{Mn}\left\{\begin{matrix}\ddot{Mn}\\ \dot{Si}\end{matrix}\right. \text{ Marceline.}$$

From this appears that all the five degrees of oxydation of manganese are isomorphous with other and corresponding oxyds. Rose suggests that the deutoxyd of manganese may be called manganous acid.—*Pogg. Ann.*, cxxi, 318. W. G.

10. *On a new cobalt compound.*—BRAUN has observed that when a solution of nitrite of potash is added to one cobalto-cyanid of potassium, a beautiful dark orange-red color is produced. When the cobalt solution is very concentrated, the solution appears intensely blood-red. The reaction succeeds in very dilute solutions of cobalt, but not in the presence of a very large excess of nickel. Braun suggests that a nitro-cyanid of cobalt is formed, and promises a further investigation of the subject.—*Journal für prakt. Chemie*, No. 2, 1864, p. 107. W. G.

11. *Indium.*—At a recent session of the Freiberg "Miners' Union," REICH communicated some further results in regard to this new metal, discovered by T. Richter and himself.[1] Two hundred pounds of black blende ore from the Himmelfahrt Mine, on treatment with chlorhydric acid, and subsequent evaporation and distillation, gave about 43 pounds of impure chlorid of zinc; this, treated with water left a residue containing indium, from which a few grams of the new element were obtained. The *metal* can be reduced from the oxyd by fusion in a carbon (brasqued?) crucible with carbonate of soda and borax, and refusion with cyanid of potassium; by fusing alone with the cyanid the oxyd is reduced, but only to pulverulent metallic powder. The density of two specimens, weighing respectively 327 and 343 milligrams, gave 7·11 and 7·14; a rolled leaflet of 415 milligrams gave a density of 7·277 at 20·4° C. The color of the metal is between tin and silver white; it is exceedingly soft and very ductile, and retains its metallic lustre when exposed to the air

[1] This Journal, [2], xxxvii, 269.

or in water, even when the latter is brought to the boiling point. Hydrogen reduces the oxyd to a metallic powder, which cannot be fused in the bulb-tube. On charcoal, before the blowpipe, it fuses easily, and, while retaining a lustrous metallic surface, colors the flame blue, and covers the coal with a coating, which is dark yellow while hot, and lighter yellow on cooling; the coating is volatilized with difficulty when treated directly with the blowpipe flame. The oxyd imparts no color to the fluxes; flamed with borax it gives a gray enamel, with salt of phosphorus and tin yields a gray pearl. The metal is slowly dissolved by chlorhydric and sulphuric acids in the cold with evolution of hydrogen; heat increases the rapidity of the solution. Dissolves rapidly in nitric acid, even when cold and dilute. The hydrated oxyd is completely precipitated from the acid solutions by ammonia and potash, is of a white color, and of a slimy consistence so that it adheres to the sides of the vessel; the presence of tartaric acid prevents this precipitation. The *oxyd* is white when cold; on heating it is colored dark yellow. Sulphuretted hydrogen gives no precipitate in nitric, sulphuric, and chlorhydric solutions of indium, but from an acetic solution it is completely precipitated as sulphid of indium, of a beautiful yellow color; this, on drying becomes nut-brown, and when pulverized it assumes an orange color. If sulphid of ammonium is added to a tartaric ammoniacal solution, a white precipitate of what may be hydrated sulphid of indium is thrown down; this, treated with acetic acid, as well as when dried and heated, becomes yellow. *Chlorid of indium*, obtained by treatment of a mixture of the oxyd with carbon in a stream of chlorine gas, forms white crystalline scales, is very volatile, attracts moisture with rapidity, and deliquesces. The hydrated chlorid is, for the most part, decomposed by evaporation, leaving a residue of oxyd of indium or basic chlorid. The *sulphate of indium* crystallizes with difficulty in indistinct scales. Carbonate of soda throws down from acid solutions a crystalline granular *carbonate of indium* of a white color. Solutions of the neutral salts of indium give with ferrocyanid of potassium a white precipitate, with ferridcyanid no precipitate.

The most striking property of the new metal, and the one which led to its discovery, is the indigo-blue line which it shows under spectroscopic examination. This is given by the metal, as well as by all the compounds thus far investigated. The chlorid gives the most brilliant effect, the sulphid is, however, the most lasting. The flame of an ordinary Bunsen-burner is colored blue when an indium-compound is brought into it.—*Berg. u. Hüttenmännische Zeitung*, xxiii, 142. G. J. B.

12. *Note on the formation of Aldehyds;* by M. Carey Lea. (Communicated for this Journal.)—M. Carstanjeu describes as new a mode of formation of aldehyds by the oxydation of substituted ammonias.[1]

This mode of formation is, however, not new. In the pages of this Journal I have already indicated it. I have shown that when triethylamin is acted upon by chlorid of gold, the gold is reduced and aldehyd given off.

[1] Rep. de Ch. Pure, 1863, p. 616, quoted from Journal für praktische Chemie.

II. MINERALOGY AND GEOLOGY.

1. *Pollux, a silicate containing a large amount of Cæsium.*—PISANI has made an analysis of this rare mineral species, and finds it to contain 34·07 per cent of cæsia, with but traces of potash. The specimens examined were obtained from the locality in the island of Elba, through Mr. L. Sæmann, of Paris. One crystal of 20 grams weight had distinct cubic faces, with trapezohedral planes like analcime, thus confirming Des Cloizeaux's optical examination, which determined the species to belong to the monometric system. The surfaces of the crystal were rough, resembling carious quartz. Lustre vitreous on the fracture, but dull and gum-like on the natural surfaces of the crystals. Colorless. H. = 6·5, G. = 2·901. In the closed tube, becomes opaque, and gives off water. In the forceps, whitens and fuses with difficulty, coloring the flame yellow. Small particles of the mineral heated with fluorid of ammonium on a platinum wire, and subsequently moistened with chlorhydric acid, give the characteristic blue lines of cæsium with the spectroscope. Slowly decomposes in chlorhydric acid with separation of pulverulent silica. The filtrate from the silica gives an abundant precipitate of the platin-chlorid of cæsium when treated with bichlorid of platinum. Analysis gave:

	Si	Al	Fe	Ca	Cs	Na*	H	
	44·03	15·97	0·68	0·68	34·07	3·88	2·40	= 101·71
Oxygen,	23·48	7·43	0·20	0·19	1·97	1·00	2·13	

* With a little lithia.

The platin-chlorid of cæsium obtained in the analysis showed traces of potash when submitted to spectroscopic examination. It was reduced by hydrogen, and subsequently the quantities of chlorine, platinum and cæsium were determined, and found to accord with theory, thus showing it to be a pure cæsium salt.—*Comptes Rendus*, lviii.

[This mineral species was previously analyzed by Plattner, who obtained:

Si	Al	Fe	K	Na*	H	
46·20	16·39	0·86	16·51	10·47	2·32	= 92·75[1]

* With a little lithia.

Pisani refers to this as an *incomplete* analysis, and remarks that as cæsium was unknown at the time when Plattner's investigation was made, that the platin-chlorid of cæsium obtained in the analyses was considered as platin-chlorid of potassium, and the amount and character of the alkalies are thus erroneously stated in the result. Calculating the amount of chlorid of potassium corresponding to 16·51 potash, we have 26·13 KCl; and converting the 10·47 soda into chlorid, we obtain 19·74 NaCl, or 45·87 alkali chlorids. Now, if we convert the 26·13 KCl into platin-chlorid of potassium, it amounts to 85·65 $KCl + PtCl_2$, and considering this to be a cæsium salt, instead of a potassium salt, it would be equal to 42·65 CsCl. As the soda in the analysis was probably calculated by ascertaining the difference between the supposed chlorid of potassium, and the total weight of alkali-chlorids, this amount is materially lessened when the chlorid of cæsium found (42·65) is subtracted from the total amount of chlorids (45·87), giving but 3·22 NaCl,

[1] Pogg. Ann., lxix, 443.

or 1·72 per cent of soda, while we have 35·69 per cent of cæsia in the mineral. Plattner's analysis would then read:

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}s$	$\dot{N}a$	$\dot{H}$	
	46·20	16·39	0·86	35·69	1·72	2·32	= 103·18
Oxygen,	24·64	7·66	0·26	2·02	0·44	2·06	

corresponding in all, except the soda, very closely with the results obtained by Pisani. The excess in both Pisani's and Plattner's analyses would seem to indicate that a portion of the alkalies in the mineral were lithia and potash, although Pisani established the absence of anything more than traces of potash in the cæsium salt obtained in his analysis. Plattner proved by experiment that neither chlorine nor fluorine was contained in the mineral.—G. J. B.]

2. *Composition of Tourmaline, Mica, Hornblende and Staurotide.*—A. Mitscherlich has found that when a gram of finely pulverized tourmaline is heated for six hours with a mixture of 9 cubic centimetres of sulphuric acid, and 6 c. c. of water in a closed tube of Bohemian glass, at a temperature of 220°–240° C., it is completely decomposed. In this manner he has been enabled to determine with accuracy the amount of protoxyd of iron contained in tourmaline and other minerals. Six specimens of tourmaline, the same as analyzed by Rammelsberg, were found to contain no sesquioxyd of iron, although at the time when Rammelsberg's investigations were made, the methods for the determination of the state of the oxydation of iron in silicates were so imperfect, that this chemist found from 4·63 to 9·33 per cent of sesquioxyd of iron in them. It was also demonstrated by Mitscherlich that there can be no sesquioxyd of manganese in tourmaline, otherwise in passing into solution a portion of sesquioxyd of iron would have been formed. He further observes, that the specimens examined were entirely free from carbonic acid, and as the method used admitted of the detection of the minutest trace of this substance, Hermann's supposition that carbonic acid is one of the constituents of tourmaline, is incorrect. Mitscherlich also decomposed several specimens of mica and hornblende by this method, and obtained results, in regard to the relative proportion of the oxyds of iron, differing very materially from those obtained by earlier analysts. Other interesting observations made in the same manner prove that the *staurotides* of St. Gotthardt, Airolo and Brittany contain no sesquioxyd of iron, although Rammelsberg's recent results gave from 2·40 to 5·21 per cent.—*Jour. prakt. Chem.*, lxxxvi, 1. G. J. B.

3. *Contributions to the chemical knowledge of several minerals; by* C. F. Rammelsberg.—I. *Kobellite.*—This species occurs at Hvena, in Sweden, associated with actinolite, chalcopyrite, and small reddish white crystals of a cobaltiferous mispickel (Kobaltarsenikkies). Kobellite resembles antimony-glance in general appearance; G. = 6·145. The analysis was made by decomposing the mineral with chlorine. It was impossible to get the mineral entirely free from the associated arsenical and copper pyrites. Composition:

	S	Bi	Sb	As	Pb	Fe	Cu	Co	
	18·22	18·60	9·46	2·56	44·25	3·81	1·27	0·68	= 98·85
Sulphur combined,		4·30	3·79	1·64	6·85	2·18	0·32	0·36	= 19·44

Especial care was taken to ascertain the absolute purity of the bismuth

and lead given in the analysis, as considerably more of lead and less of bismuth were found than obtained in the previous analysis by Setterberg. The cobalt was considered as due to the cobaltiferous mispickel, which with the formula $(CoS^2+CoAs)+4(FeS^2+FeAs)$ would correspond to 5·61 per cent. In the same manner, the copper calculated as chalcopyrite equals 3·67 per cent. These amounts subtracted from the analysis, and the remainder averaged up, gives for the composition of pure kobellite:

	S	B	Sb	Pb	Fe
	17·47	20·52	10·43	48·78	7·55 = 98·75
Sulphur combined,		4·73	4·18	7·55	0·88 = 17·34

Rammelsberg writes the formula, $(PbS)^3\,BiS^3+(PbS)^3SbS^3$=S 16·82, Bi 18·23, Sb 10·54, Pb 54·41 = 100.

II. *Siegenite.*—A new analysis of the so-called siegenite (Kobaltnickelkies) from Müsen shows that the earlier analyses of this mineral are erroneous. This is due to the fact that at the time they were made no sufficiently accurate method was known for the separation of cobalt and nickel. The separation of these metals was effected by means of nitrite of cobalt. Analysis of the crystals, selected as pure as possible from associated chalcopyrite, gave: S 42·76, Co 39·35, Ni 14·09, Cu 1·67, Fe 1·06 = 98·93. Considering the iron as combined with 1·21 sulphur and 1·20 copper, forming chalcopyrite, and subtracting these from the analysis, the composition of the pure mineral is as follows:

S	Co	Ni	Cu
43·04	40·77	14·60	0·49

giving the established formula $RS+R_2S_3$. The amount of cobalt found in former analyses was 22·09 and 11·00 per cent, while the nickel varied from 33·64 to 42·64. This difference is due chiefly to the imperfect method previously used in the separation of the nickel and cobalt, and not to varying composition of the mineral, although another specimen gave on analysis, 36·82 cobalt and 17·72 nickel. A specimen of cobaltine from Tunaberg was found to contain 0·64 per cent of nickel, and another specimen of the same species from Skutterud contained 0·48 per cent, showing that the present method of separating these metals is far more delicate than that formerly employed. [Plattner has previously shown that cobaltine contained traces of nickel.—*Löthrohr-Probirkunst*, p. 318. —G. J. B.]

III. *Vivianite.*—An analysis of the vivianite from Allentown, Monmouth, Co., New Jersey, gave:

	$\dot{P}$	$\dot{F}e$	$\dot{F}e$	$\dot{H}$
G. = 2·68.	28·81	4·26	38·26	28·67 = 100
Oxygen,	16·23	1·28	8·50	25·48

The mineral occurred in concentric radiated crystals of a light bluish-green color.

IV. *Analyses of Tremolite and Diopside from Gulsjö.*—In confirmation of *Rammelsberg's* view in regard to the composition of those varieties of pyroxene and hornblende which are free from alumina, he now gives further analyses, one of tremolite and another of diopside, from Gulsjö:

	Si	Mg	Ca	Fe
Tremolite (G. = 3·003),	57·62	26·12	14·90	0·84 = 99·48
Diopside (G. = 3·249),	55·11	18·39	25·63	0·54 = 99·67

Both analyses give almost precisely the ratio of bases to silica of 1 : 2.

V. *Skolopsite.*—This mineral, described by v. Kobell, occurs at Kaiserstuhl, forming a crystalline granular mixture with a dark green pyroxene. Pure fragments are colorless and transparent, but the larger masses have a gray, greenish or reddish color. Gelatinizes with chlorhydric acid, giving off a trace of sulphuretted hydrogen, and sometimes a little carbonic acid from adhering calcite; this solution contains sulphuric acid. When the decomposition has been effected with nitric acid, chlorine may be detected by nitrate of silver.

The results of the analyses, after deducting the associated augite, were:

	Cl	S	Si	Al	Fe	Ca	Mg	Na	K	H	
1,	1·36	4·62	35·41	21·39	2·24	15·50	2·31	12·17	2·87	3·29	
2,		4·17	34·17	20·61	3·16	14·70	3·04	11·74	2·73		
Mean,	1·36	4·39	34·79	21·00	2·70	15·10	2·67	11·95	2·80	3·29	= 100·05
Oxygen,	0·31	2·63	18·25	9·83	0·81	4·31	1·07	3·09	0·47	2·92	
				10·64		8·94					

The chlorine replaces 0·31 oxygen, and the sulphuric acid requires 0·88 oxygen to form a sulphate of a protoxyd base; this amount (0·31 + 0·88), subtracted from the oxygen of the protoxyds, leaves 7·75, which number added to 10·64, the oxygen of the sesquioxyds, equals 18·39, almost exactly the same as the oxygen of the silica: giving the ratio of 1 : 1 between acid and bases, and of 2 : 3 between the protoxyds and sesquioxyds. Rammelsberg writes the formula, $2\dot{R}^2\ddot{S}i + \ddot{R}^2\ddot{S}i^3$, which would be a ratio of 2 : 2 : 5, instead of 2 : 3 : 5. He considers it analogous to Sodalite, Nosean, etc., and, inclusive of the chlorid and sulphate, gives the following formula for the mineral, $2RCl + 3(2\dot{R}_2\ddot{S}i + \ddot{R}^2\ddot{S}i_3) + 3[2\dot{R}\ddot{S} + 3(2\dot{R}^2\ddot{S}i + \ddot{R}^2\ddot{S}i_3)]$.

VI. *Pyroxene.*—Analysis of the dark-green augite associated with skolopsite:

Si	Al	Ca	Fe	Mg	Mn	
48·02	2·67	25·34	13·57	9·74	1·28	= 100·62

—*Jour. prakt. Chem.*, lxxxvi, 340. G. J. B.

4. *On a Volcanic Island in the Caspian;* by Count Marschall of Vienna.—The existence of this island was first made known by Captain Koumani, of the Russian schooner Jourkmen, on the 7th of May, 1861. Its situation is in 39° 34′ 14″ N., and 47° 15′ 20″ E. from Paris. At the time of its discovery it was 400 to 500 paces in circuit, elliptical in outline, and in surface a plain slightly elevated at centre. About the highest point, which was between 18 and 19 feet above the level of the sea, there were small depressions containing muddy waters from which gases were escaping; the temperature of the waters, according to Mr. Abich's observations, was 28°·4 R., that of the air being 20°·3 R. On the 20th of June, 1861, its elevation was only 12 feet; near the close of July but 6 feet; and towards the end of that year it had sunk to 2 feet below the level of the sea. It continued to sink in 1862, and soundings over it, taken in January, 1863, gave depths of 12 to 13 feet.

The region of which the Caspian sea is the centre, and especially the peninsula of Abcheron, presents almost constant volcanic phenomena in its naphtha springs, mineral and gaseous waters, and occasional muddy eruptions, and sometimes also is disturbed by igneous eruptions, and by earthquakes, as recently those of May 30, 1831, and June 11, 1859.—*Les Mondes*, v, 106, *from the Institut Imp. Geol.* 1863.

5. *Notes on the Geology and Mineralogy of the Spanish Province of Santander;* by Wm. K. Sullivan, Ph.D., M.R.I.A., Prof. Chem. Catholic Univ. of Ireland, &c., and Joseph P. O'Reilly, C.E. 196 pp. 8vo. With maps, views and sections. London and Edinburg. Williams & Norgate. First published in the *Atlantis*, vol. iv.—Santander is one of the northern provinces of Spain, lying on the Bay of Biscay. This work treats of the Physical Geography of the Province, and its general geology, and particularly of its metalliferous deposits, mining industry, and ores, and is illustrated by a number of detailed maps. The subject of the ores is treated mineralogically and chemically, and also with reference to their geological age and the order of succession according to which the different kinds were formed. A chapter containing five plates is devoted to the deposit of sulphate of soda in the valley of the Jarama near Aranjuez, Province of Madrid; and another to observations on the mammillated, reniform, globular and botryoidal structure in minerals.

6. *Notes on a Cave and Coal Pit near Peking;* by S. Wells Williams.—Among the interesting objects of investigation in the vicinity of Peking, the coal and lime pits, and the caves near them, have attracted several visitors. They all lie within a few miles of each other on the lowest hills of the mountain range which forms the beginning of the ascent to the Table Land of Central Asia, and closes the northern side of the Great Plain of Eastern China, a few miles west of the capital.

The road thither leaves the southwestern gate of Peking on the great stone causeway that was laid by the Emperor Kanghi, and goes on to *Lú-kau-kiau*, about eight miles, where it ends.

From this spot the road to the mines leads through the district city of *Liáng-hiáng-hien*, a town situated in the midst of well cultivated fields, but greatly dilapidated in its walls and gates, showing the poverty of the people and neglect of the officers. Seven miles farther on is the district city of *Fangshan*, much better built and cared for, as its comparatively wide streets, solid double gates, and well stocked markets attest. Between these two towns, and also nearer the base of the hills, are several channels, in which very large boulders and much water-worn shingle prove the great quantity and force of the torrents that occasionally flow from the mountains, though during most parts of the year a brooklet hardly finds its way down the dusty bottom.

The village of *Kuh-shan-kau* lies at the base of the hills in which the caves occur, and, at the time of our visit, near the autumnal equinox, was filled with animals laden with the harvest, which the peasantry were bringing in from the surrounding fields.

In the morning, we started with a guide for the principal cave, called *Yun-shwiu-tung*, or Cloud-water cave, situated about 1,500 feet above the valley. The rock throughout this region is metamorphic limestone, fertile wherever it is covered with soil; the hillsides are hidden with veg-

etation, so that the winding path led up through a succession of pretty spots and along the brink of cliffs, all in charming variety, and, at this time, adorned by myriads of autumnal flowers in full bloom. The mouth of the cave is protected by a shrine and temple—three or four ancient and dilapidated buildings under the charge of a superannuated priest, whose vacuity, senility and dirt comported with the dusty and faded gods committed to his keeping. He was a painful object, but did his best to entertain us, assisted by a laic who is the guide into the cave.

The throat of the cave just admits a man to crawl on his knees about twenty steps, when he enters a room of irregular shape, some 80 by 30 feet in extent, and rising here and there 50 feet high, with an uneven floor, on which stalagmites had formed a thick crust. The walls were black with smoke, and no stalactites of any size were in this room. A gradual descent led to a still narrower but short gullet opening into other rooms; one was full of stalagmites. This long fissure in the rocks presented a more pleasing variety of grotesque rocks, which have been named the seat of Kwanyin, the Pearl rock, the Eighteen Rahan, the Lotus Stalk, and such like fanciful names, all of which were duly pointed out by the talkative guide. Some pretty pieces of alabaster were clipped from one of them. Another turn carried us off nearly at right angles, and further progress was soon stopped by water—a pool lying across the path. We were told that the end had never been reached in consequence of this obstruction, and legends of adventurous explorers who have perished in the search are told to inquiring travellers. The entire distance through is about half a mile, and the end of the cave is somewhat lower than the entrance. No petrifactions or fossils have yet been found, but it is not improbable that some might be discovered under the floor of the cave, for its conformation and position are very similar to the fossil caves of Gailenreuth in Germany.

The path back to the Tsieh-tái Gan led over the ridge into the upper part of the valley, where most of the convents are situated, grouped in clusters of houses as space has been found for them on one side or the other of the stream. During this winding walk over the cliffs and along the edge of precipices, scenes of great beauty were continually opening from one point to another, which beguiled the fatigue and rewarded the toil. One hermitage was perched far above on the opposite ridge, attainable by a toilsome ascent of nearly 2,000 feet; and others lay lower down. The hills are known as the *Fáng-shan*, or Square Peaks, but each monastery has its own name, and is devoted to some Budhist saint or legend. The valley is too narrow to be cultivated, but small plats, near the houses, furnish a few vegetables and flowers. Nearly at the bottom is a sheer descent of about 300 feet, over which the water occasionally pours in quantity with no small foam and noise. The temple placed at the top of this cascade is most romantically situated; and if the constant contemplation of the beauties and wonders of creation had, of itself, any power to lead the mind up to the knowledge of their creator, the priests, who have chosen this place for their prayers, should certainly be among the most devout. From one temple to another, all the way down, the priests received us courteously, and were curious to learn where the *Ta-mei-kwoh*, i. e. the United States, was situated; but those living

at this spot were more interested than the others. The steps leading to it are chiseled out of the sides of the rock, and chains are hung along to assist the passenger in making the toilsome ascent.

A roughish path leads from the mouth of this valley to the coal mines over a steep hill into a broader one, where the vegetation is less abundant. The lime-kilns are conspicuous from their white debris scattered over the ground for a good distance around; the lime is excellent; it is burned with coal, but the kilns were not in operation at the time of our visit, nor were they ever extensively worked. They lie about two miles northerly from Kuh-shan-kau, and the coal pits are three miles farther, up a steep ravine or woody opening into the main valley, the path to them rough and stony in the extreme. There are about fifteen shafts open, each of their entrances being enlarged into a room where the colliers sleep and eat at times, though more comfortable dwellings have been built for overseers and contractors.

We engaged a miner to show us down the largest shaft, which measured on the average only 4½ feet high by 5 wide; it is cased with willow sticks in a secure manner, and the roof is particularly well guarded. The bottom is lined with the same to form a ladder, up and down which the miners travel in their daily labor. This shaft is about 150 feet deep, and the ladder down to the digging is perhaps 600 feet long. The coal is secured on small wooden sledges, and drawn, as the miner slowly crawls up along the narrow and slippery steps, by a strap passing over his forehead, each load weighing 80 catties. One workman brings up six loads as his day's work. The sides of this shaft showed the width of the veins of coal, but the top and bottom were not dug out; at the bottom the shaft divided and led toward two deposits, but neither passage had been dug out. The whole was very dry, owing probably to its elevation up the hill; but some shafts had been abandoned from wet and bad air, and their mouths closed. The laborers are hired out by contractors, who sell their coal to the dealers coming from Peking and elsewhere; it is all carried away on the backs of camels or mules, and it was a painful sight to see the unwieldy camels coming down the rocky, uneven road, bringing their loads of coal. It is delivered in Peking at about three piculs for a dollar, and a large part of the price is for carriage. The coal is hard, but such examination as the time afforded disclosed not a vestige of a stump or leaf to compare with the fossils of other coal regions; more careful research will doubtless bring to light some indications of this kind, enabling scientific men to compare the numerous deposits of soft and hard coal in this part of China with the European coal-measures.—*China Mail, Nov.* 26, 1863.

7. *On the probable identity of the Oneida Conglomerate of Central New York with the Medina formation.*—E. JEWETT, Curator of the State Collections at Albany, N. Y., in a letter to one of the editors, states that he has found the *Fucoides* (*Arthrophycus*) *Harlani*, a characteristic Medina fossil, in the Oneida Conglomerate, near Utica, Oneida Co., N.Y., and concludes on the ground of this discovery, and also, as he observes, for stratigraphical reasons, that the Oneida conglomerate is in fact only a northern portion of the Medina sandstone. The occurrence of this or a related Fucoid is stated by Dana in his Manual of Geology (p. 230), a specimen

having been obtained from the rock near Utica by the author more than thirty years since, which was in all probability of the same species, although, as the specimen was afterwards lost, the fact is given in the Manual with a query as to the species. J. D. D.

8. *Coal in the Alps of Mt. Cenis.*—Mr. DICKINSON exhibited to the Geological Society of London, at its meeting on Feb. 23d, a number of specimens taken from the rocks now being tunneled through the Savoy side of Mont Cenis. They are principally from metamorphic rocks, and as yet no granite has been touched upon. The most interesting mineral of all is the coal, which is found associated with these metamorphic rocks. It has been cut through in different places in the tunnel. Between San Michel and Modan similar coal is being worked to supply the district. It is anthracite coal, very similar to the Welsh anthracite. There is no regular dip in any of these rocks. In one part they are seen standing up like a cone, the coal sometimes vertical, and dipping in a variety of directions.—*Reader, April* 16.

9. *New Fossils from the Lingula-flags of Wales;* by J. W. SALTER, Esq.—Since the author's paper at the last session of the Geological Society on the discovery of *Paradoxides* in Britain, the researches of Mr. Hicks have brought to light so many new members of the hitherto scanty fauna of the Primordial zone that Mr. Salter was now enabled to describe two new genera of *Trilobites* and a new genus of sponge, and to complete the description of *Paradoxides Davidis.* He also remarked that the fauna of the Lingula-flags shows an approximation in some of its genera to Lower Silurian forms, and some—the shells and a Cystidean—are of genera common to both formations; but the Crustaceans, which are the surest indices of the age of Paleozoic rocks, are of entirely distinct genera; and their evidence quite outweighs that of the other fossils. The Primordial zone is, moreover, in Britain separated from the Caradoc and Llandeilo beds by the whole of the Tremadoc group, at least 2000 feet thick.—*Proc. Geol. Soc., May* 23, in *Reader, Ap.* 9.

III. BOTANY AND ZOOLOGY.

1. *Heath* (*Calluna vulgaris*) *in North America.*—The earliest published announcement that we have been able to find of *Calluna vulgaris* as an American plant, is that by Sir Wm. Hooker, in the Index to his *Flora Boreali-Americana* (2, p. 280), issued in 1840. Here it is stated that: "This should have been inserted at p. 39, as an inhabitant of Newfoundland, on the authority of De la Pylaie." Accordingly, in the 7th volume of De Candolle's *Prodromus*, to the European habitat is added, "Etiam in Islandia et in Terra Nova Americæ Borealis." But it does not appear that Mr. Bentham had ever seen an American specimen. He also overlooked the fact (to which Dr. Seemann has recently called attention) that Gisecke, in Brewster's *Encyclopædia*, records it as a native of Greenland. No mention of it is made by Dr. Lang, in his enumeration of the known plants of Greenland, appended to Rink's Geographical and Statistical Account of Greenland, published in 1857,—from which we may infer that the plant is perhaps as rare and local in Greenland as in Newfoundland or even in Massachusetts!

In this Journal, for September, 1861, the present writer announced

the unexpected discovery, by Mr. Jackson Dawson, of a patch of Heath in Tewksbury, Massachusetts; adding the remark, that: "It may have been introduced, unlikely as it seems; or we may have to rank this Heath with *Scolopendrium officinarum*, *Subularia aquatica*, and *Marsilea quadrifolia*, as species of the Old World so sparingly represented in the New, that they are known only at single stations,—perhaps late-lingerers rather than new-comers." And when, in a subsequent volume of this Journal, Mr. Rand, after exploring the locality, gave a detailed account of the case, and of the probabilities that the plant might be truly native, we added a note to say that the probability very much depended upon the confirmation of the Newfoundland habitat. As to that, we had been verbally informed, in January, 1839, by the late David Don, that he possessed specimens of *Calluna* collected in Newfoundland by an explorer of that island. Our friend Mr. C. J. Sprague, however, after having in vain endeavored to find in any publication of Pylaie's any mention of this Heath in Newfoundland, and having ascertained that no specimen was extant in Pylaie's herbarium, or elsewhere that he could trace, naturally took a skeptical view, and in the Proceedings of the Boston Natural History Society for February and for May, 1862, he argued plausibly, from negative evidence, against the idea that any native Heath had ever been found in Newfoundland or on the American continent. It is with much interest, therefore, that we read the announcement by Dr. Hewett C. Watson (in the Natural History Review for April last), that—

"Specimens of *Calluna vulgaris* from Newfoundland have very recently come into my hands, under circumstances which seem to warrant its reception henceforth as a true native of that island. At the late sale of the Linnæan Society's Collections in London, in November, 1863, I bought a parcel of specimens, which was endorsed outside, "A collection of dried plants from Newfoundland, collected by — McCormack, Esq., and presented to Mr. David Don." The specimens were old, and greatly damaged by insects. Apparently, they had been left in the rough, as originally received from the collector; being in mingled layers between a scanty supply of paper, and almost all of them unlabelled. Among these specimens were two flowerless branches of the true *Calluna vulgaris*, about six inches long, quite identical with the common heath of our British moors. Fortunately, a label did accompany these two specimens, which runs thus:—"Head of St. Mary's Bay—Trepassey Bay, also very abundant.—S.E. of Newfoundland considerable tracts of it." The name "*Erica vulgaris*" has been added on the label in a different handwriting. All the other species in the parcel (or nearly all) have been recorded from Newfoundland, so that there appeared no cause for doubt respecting the *Calluna* itself. And, moreover, the Collector had seemingly some idea that an especial interest would attach to the *Calluna*, since in this instance he gave its special locality, and also added two other localities on the label. But there is very likely some mistake in the name of the donor to Mr. Don. It is believed by Sir William Hooker that he was the same Mr. W. E. Cormack, whose name is frequently cited for Newfoundland plants in the "Flora Boreali-Americana." This gentleman was a merchant in Newfoundland, to which he made several voyages.

We should recollect that the *Calluna* advances to the extreme western limits (or out-liers) of Europe, in Iceland, Ireland, and the Azores. The step thence to Newfoundland and Massachusetts, though wide, is not an incredible one."

Without doubt these are the very specimens referred to by Mr. Don, then curator of the Linnæan Society. And now that the stations where they were collected are made known, we may expect that the plant will soon be rediscovered, and its indigenous character ascertained.

We notice that an earlier announcement of Dr. Watson's discovery is contained in Dr. Seemann's Journal of Botany for February last, where the record of Gisecke's discovery of *Calluna* in Greenland is referred to. In view of this, and of its common occurrence in Ireland, Iceland, and the Azores, Dr. Seemann opines that "its extension to Newfoundland and the American continent is therefore not so much a paradox as a fact at which we might almost have arrived by induction." It seems to us that the *induction* was all the other way until the plant was actually discovered on American soil. A. G.

2. *Lessons in Elementary Botany: The part on Systematic Botany based upon material left in manuscript by the late Professor Henslow; with numerous illustrations;* by DANIEL OLIVER, F.R.S., F.L.S., *Keeper of the Herbarium and Library of the Royal Gardens, Kew, and Professor of Botany in University College, London.* London and Cambridge: Macmillan & Co., 1864. pp. 317, 24mo.—As a simple introduction to Botany for beginners, this little volume, which has just reached our hands, appears to be almost unrivalled. It is very simple, but truly scientific, and written with a clearness which shows Professor Oliver to be a master of exposition. The elements of Structural and Physiological Botany are presented in eight chapters, occupying a little more than a third part of the book, not in strict systematic order, but in a series of lessons upon familiar plants, beginning with a Buttercup. Three short and easy lessons are devoted to the Buttercup, upon which all the organs of a flowering plant and their functions are compendiously taught. The fourth lesson introduces "Common flowers to compare with Buttercup," viz: Wallflower, Pea, Bramble, Apple or Pear, Cow Parsnip or Carrot, Daisy, Dead-Nettle, Primrose, Stinging Nettle; bringing out clearly the general morphology of the flower, and the characters of the great exogenous or dicotyledonous class. The fifth deals with Arum, Spotted Orchis, Daffodil, Tulip, and Wheat; bringing out the characters of the monocotyledonous class. The sixth introduces the use of "Flower-schedules," upon a plan devised and successfully employed by the late Professor Henslow; a good mode of directing attention to the more important points in the structure of flowers, and of training young pupils to precise observation. The seventh lesson sketches the development and morphology of the organs, from root to seed, in regular order. The eighth is devoted to the anatomy, or "the minute structure and vital processes of plants." The second part, on "The Classification of Plants," after a few well-chosen remarks on the plan and nature of classification and binomial nomenclature, illustrates by means of common types the natural orders of British plants, their sensible properties and common uses. And finally, an appendix explains how to dry plants, and, by a set of examples,

how to describe them in botanical language. No one would have thought that so much thoroughly correct botany could have been so simply and happily taught in so small a volume. A. G.

3. *Radicle-ism.*—That the stem or ascending axis in Phænogamous and the higher Cryptogamous plants is composed of a series of similar parts, viz: of nodes or leaf-bearing points separated by internodes, each internode developed from the summit or node of its predecessor, is the fundamental doctrine in structural botany. That the embryo (with undeveloped plumule) is simply the initial term of the series; that its so-called *radicle* is not root, but answers to internode, just as the cotyledons borne on its summit answer to leaves, are propositions which we suppose are generally accepted on the continent of Europe, as they certainly are by the botanists of this country. Simple, clear, and indubitable as this view appears to us, our endeavors to impress it upon English botanists, although likely to succeed in the end, make slow progress. Some of these endeavors, or protests, are recorded in this Journal, e. gr., in the nos. for Nov., 1857, p. 435; in Nov., 1858, p. 416; in July, 1861, p. 126; in Sept., 1863, p. 291; and finally in Nov., 1863, p. 435. In the article last referred to, we noted what we took for an admission decisive of the question, viz: that "the radicle is rightly regarded as an axis and not a root." The word 'axis,' as here used in contradistinction to 'root,' we understood to mean ascending axis or stem. We were hasty, it appears; and our mistake arose from our not considering a third possible alternative, i. e., that the radicle might be *neither* root *nor* stem, but a *tertium quid*. This very view is now propounded by Prof. Oliver, in the Natural History Review for April last (p. 314), in an article which, replying as it does to our criticism, may be presumed to express the opinion of Dr. Hooker also. Propounded by such authorities, the view is entitled to the most attentive consideration.

Upon it we remark, first, that, as it introduces a new element into the structural composition of the plant, the burden of proof rests upon the propounders. In what we supposed to be the accepted view, we have the plant built up by the successive repetition of homologous parts, of superposed joints of stem, each bearing a leaf or leaves at its superior extremity, and each capable of sending out a root or roots, actually producing them under favorable circumstances, preferentially at the lower extremity. It being conceded that the radicle of the embryo is not root, but that from the base of which the primary root is produced, while its other end is a leaf-bearing node, the inference is natural that it is the primordial internode, the initial joint of stem. Such inference must be rebutted by evidence,—by showing, for instance, that the radicle has not the structure or the behavior of an internode. Prof. Oliver supports his denial of our proposition, that the radicle answers to an internode of the ascending axis, by two arguments,—one of which is stated *in extenso*, but may be shortly expressed, and as shortly answered. It is, that an internode, being in terms the part between two nodes, and there being a node only at the upper end of the radicle, none at the lower, therefore the radicle cannot be an internode! This is *literally* true. The series of nodes and internodes—not being infinite, nor in a circle like the old Egyptian symbol of a serpent with its tail in its mouth—must needs be-

gin with the one or the other; and in our view it begins with internode, i. e. with axis itself, and not with leaf-bearing apex of axis. But if the *name* here really confuses any one's ideas as to the *thing*, let us substitute for *internode*, Gaudichaud's original technical term of *merithallus* or *merithalle*, and so have done with this verbal argument.

The other argument, to prove that the radicle is a *tertium quid*, is, that in some respects the behavior of the axis below the cotyledonar node is dissimilar to that above, "apart, of course, from the circumstance that the one develops a succession of leaves, the other a root." But the radicle bears the cotyledons, and therefore begins this very succession of leaves,—is to the cotyledons and the plumule just what the next *merithalle* is to its leaf or leaves and the terminal bud; and any of these merithalles, if under ground, will be pretty sure to produce roots;—would produce a root directly from their lower end, no doubt, were that not impossible under the circumstances. What the other dissimilarities are is not suggested. Perhaps Dr. Hooker has alluded to them in his admirable Memoir on *Welwitschia* (p. 17), in his references to the papers of Clos in the *Ann. Sci. Nat.*, on the *collet* and on *rhizotaxie*. Upon which it may suffice to remark, that, whatever minor discrepancies there may be between the number and disposition of the vascular bundles in the axis above and below the cotyledons, they seem capable of easy explanation; and that we should refer to those very figures by Clos, in *Ann. Sci. Nat.*, 3, 18. t. 16 and 17, and to the original subjects which can so readily be examined, as evidence that the radicle, as to internal structure, is stem.

Upon this very ground of internal structure; upon its mode of increase in length (elongating throughout, and often, as in *Cucurbitaceæ*, in Beans, &c., continuing to elongate in its upper portion long after the portion toward the root has ceased to lengthen); indeed, upon its whole behavior (lengthening in some cases, remaining undeveloped in others); upon what it bears; and upon every comparison which we have yet been able to make, we are bound still to maintain that the radicle is not a *tertium quid*, but *is* "to be regarded as part of the stem or ascending axis, in the same sense as the other internodes of the plant may be so regarded." If an opposite view is tenable, we crave an explicit statement of the grounds upon which it is maintained. A. G.

4. *Göthe's Essay on the Metamorphosis of Plants*, translated into English by Emily M. Cox, is published in Dr. Seemann's Journal of Botany, for November and December last. The translation is augmented by some explanatory foot-notes by Dr. Masters, which will aid the general reader to a correct understanding of this celebrated essay. It would be well to translate and reprint Wolff's *Theoria Generationis* also. A. G.

5. *Equisetum.*—In the same useful Journal (for November, 1863,) is a translation of a paper by Dr. Milde, On the Geographical Distribution of the *Equisetaceæ*. In the summary it appears that—

At present only 26 pieces of *Equisetum* can be distinguished with certainty, viz: ten E. PHANEROPORA, *E. arvense* L., *E. Braunii* Milde, *E. Telmateia* Ehr., *E. sylvaticum* L., *E. diffusum* Don, *E. Bogotense* H. & Bonpl., *E. palustre* L., *E. limosum* L., and *E. littorale* Kühler); and sixteen E. CRYPTOPORA, (*E. Martii* Milde, *E. xylochætum* Metten.,

E. Brasiliense Milde, ***E. Schaffneri*** Milde, ***E. giganteum*** L., ***E. myriochætum*** Schlecht. & Cham., ***E. debile*** Roxb., ***E. Mexicanum*** Milde, ***E. elongatum*** Willd., ***E. robustum*** A. Braun, ***E. lævigatum*** A. Braun, ***E. hiemale*** L., ***E. Schleicheri*** Milde, ***E. trachyodon*** A. Braun, ***E. variegatum*** Schleich., and ***E. scirpoides*** Michx. It appears that Dr. Seemann has an additional species from the Feejee Islands.

E. elongatum is the most widely dispersed species, viz: in Europe to lat. 51°, N. Asia, North and South Africa, Mexico, and Chili.

Europe with thirteen species does not possess a single peculiar one, strictly speaking, *E. littorale* being a hybrid, and *E. Schleicheri* and *E. trachyodon* being regarded as only subspecies.

America contains the greatest number of species (21), and those of South America are the most peculiar. *E. xylochætum* of Peru, and *E. Brasiliense* of Brazil, have the stem 10 feet high and an inch in diameter; while *E. Martii*, found in both these countries, is still more gigantic. *E. myriochætum*, one of the five known Mexican species is likewise gigantic. Northern N. America has nearly all the European species, viz: *arvense*, *pratense* (Labrador), *sylvaticum*, *palustre*, *limosum*, *hiemale*, *variegatum*, and *scirpoides;* likewise the striking *E. Telmateia* about the northern Great Lakes; also the Californian species confounded with the latter, *E. Braunii* Milde, and A. Braun's *robustum* and *lævigatum*, the former extending into Mexico. A. G.

6. *A. Braun on Marsilia and Pilularia.*—As a precursor to an extended monograph, Prof. Braun has brought out, in the Proceedings of the Berlin Academy, in 1863, a full list and arrangement of the species of *Marsilia* (as he, with evident correctness, writes the name). He recognizes 37 species, seven of them, however, perhaps to be merged in others. As to geographical distribution, 4 are found in Europe, Northern Africa and Asia, 6 in Southern Asia, 12 in Central and Southern Africa and the islands adjacent, 9 in North and South America—one of which is common to both North America and Europe,—5 in Australia, and 4 in the South Sea Islands—only two of which, however, are peculiar to them. The species enumerated from North America, including Mexico, are as follows, under their respective sections.

A. Fruits 8 to 20, placed on recurved peduncles in a single row far up the petiole, from the outer edge of which they spring, globose, without teeth.

M. polycarpa, Hook. & Grev. Mexico and southward.

B. Fruits 2 to 6, mostly 2 (exceptionally 1), seated on a little above the base of the petiole, more or less compressed, mostly oblong, with two teeth. (Peduncles erect, confluent for some distance, sometimes more than half way up.)

M. quadrifolia, L. Connecticut, at only one known locality, where it was discovered by Dr. T. F. Allen. (Temperate Europe and Asia.)

M. macropus, Engelm. (non Hook.) Texas.

C. Fruit solitary at the base of each petiole, more or less compressed, with or without teeth. (Peduncles erect or ascending.)

M. uncinata, A. Braun. Arkansas, Texas.

M. mucronata, A. Braun. (*M. vestita*, Torr.) Minnesota.
M. vestita, Hook. & Grev. Oregon, New Mexico.
M. tenuifolia, Engelm. Texas.

Prof. Braun also enumerates four species of *Pilularia*. Under the division with peduncles erect, *P. globulifera* L., the original species, of Europe and Northern Asia. Under the other division, with peduncles bent downward, there is *P. minuta* Durieu, from the Mediterranean region; *P. Novæ Hollandiæ* A. Braun, of Australia; and, which is especially interesting, *P. Americana* A. Braun, from Arkansas!

The above account is abstracted from the notice in Dr. Seemann's Journal of Botany. A. G.

7. "*A National American Herbarium.*—Two years ago, Prof. Asa Gray made the munificent offer to the University of Cambridge, Massachusetts, of his valuable Herbarium and Library, upon condition that a suitable fire-proof building should be erected for their reception, and a fund invested for their adequate maintenance. The subject has been in abeyance until recently, when a banker of Boston liberally offered to defray the cost of the required building, provided others raised a fund to meet the current expenses of the establishment. We rejoice to find that this truly national collection, of the greatest importance to American Botany, is in a fair way of being disposed of in accordance with Dr. Gray's views. We understand, moreover, that this Herbarium is likely to prove a nucleus around which other collections of much importance will probably accumulate.

"We sincerely hope that, through the well-known liberality of American citizens, this Herbarium and Library may be put upon such a footing that Prof. Gray may be so far relieved of its management as to be able to devote himself to the object which we know to be very near his heart —the completion of a Flora of the North American Continent. For this great work Professor Gray has accumulated a very large amount of material; and no botanist is more thoroughly qualified in every way to carry out such an undertaking."—*Nat. Hist. Rev.*, London, April, 1864, p. 313.

8. *Annual Report of the Trustees of the Museum of Comparative Zoology of Cambridge, together with the Report of the Director*, 1863. 56 pp., 8vo. 1864.—The Museum of Comparative Zoology at Cambridge, under the direction of Prof. Agassiz, is making rapid progress in the enlargement of its collections and the arrangement of the specimens. The additions during the year 1863 are as follows:

	Species.	Specimens.
Mammals,	117	206
Birds,	820	1676
Reptiles,	183	1984
Fishes,	630	4537
Insects,	Between 2000 and 3000	Nearly 17000
Crustaceans,	273	3042
Mollusks,	1443	33,594
Echinoderms,	240	1912
Acalephs,	40	175
Polyps (and Corals),	125	1006

It is also doing much work in investigation, and in exchanges with her institutions both European and American.

The Museum has a grant from the Legislature of Massachusetts of $10,000 for the publication of an illustrated catalogue, the first part of which is already in the press. An important feature in the Museum is the collection of diagrams and drawings of minute species, or of those that lose their form in alcohol, on which Prof. Agassiz remarks as follows:

"For many years past I have caused diagrams to be drawn to illustrate more fully those specimens in the Museum, the characteristics of which are not easily preserved in the usual mode of exhibiting objects of natural history. Many animals are so very small that, unless they are magnified, their peculiarities are not readily perceived; others contract so much when preserved in alcohol, or lose their natural form and color to such an extent, that they appear like shapeless masses in the jars in which they are put up; still others are so delicate in their structure that they can hardly be preserved at all. It appeared nevertheless desirable that all these objects should be exhibited to the eye of the student as fully as the largest animals which from their very nature may easily be preserved either whole or in parts. The simplest way to attain this end was to have enlarged drawings made of all these objects, either from living specimens or copied from works not readily accessible to the students of natural history, in which satisfactory illustrations may have been published. Many hundreds of these diagrams have already been made by my friend Mr. Bourkhardt, some of which are now on exhibition in the Museum, and in a few weeks every available space in our public rooms will be occupied by those which thus far have remained in portfolios. This will greatly add to the interest of our collections and form a novel feature in the Museum, which I have no doubt will soon be imitated by others."

9. *Observations on the development of Raia Batis;* by JEFFRIES WYMAN, M.D., Hersey Prof. Anat. in Harvard College. 14 pp. 4to, with a plate. (From the Memoirs of the American Academy, vol. ix, pp. 31–44.)—These investigations by Dr. Wyman were made on a series of eggs collected in the spring of 1851 and of the three subsequent years. The more important conclusions arrived at are stated as follows at the close of the paper:

(1.) The yelk case is formed in the glandular portion of the oviduct, and is begun previously to the detachment from the ovary of the yelk which is to occupy it.

(2.) The embryo, before assuming its adult form, is at first eel-shaped, and then shark-shaped.

(3.) The embryo is for a short time connected with the yelk by means of a slender umbilical cord; the cord afterward shortens, and the young skate remains in contact with the yelk until the end of incubation.

(4.) There are seven branchial fissures at first; the foremost of these is converted into the spiracle, which is the homologue of the Eustachian tube and the outer ear canal; the seventh is wholly closed up, and no trace remains; the others remain permanently open.

(5.) There are no temporary branchial fringes or filaments on the first and seventh arches; on the others the fringes are developed from the outer and convex portion of the arch, and are not at first prolongations of the internal gills.

(6.) The nostrils, as in all Vertebrates, consist at first of pits or indentations in the integuments; secondly, a lobe is developed on the inner border of each; and, finally, the two lobes become connected, and thus form the homologue of the fronto-nasal protuberance. The transitional stages of these correspond with the adult conditions of them in other species of Selachians.

(7.) The nasal grooves are compared with the nasal passages of air-breathing animals, and the cartilages on either side of these to the maxillary and intermaxillary bones.

(8.) The foremost part of the head is formed by the extension of the facial disk forward; while this extension is going on, the cerebral lobes change their position from beneath the optic lobes to one in front of them.

(9.) Two anal fins, one quite large and the other very small, are developed, but both are afterward wholly absorbed.

(10.) The dorsals change position from the middle to the end of the tail. At the time of hatching, however, there is still a slender terminal portion of the tail, which is afterward either absorbed or covered up by the enlarged dorsals, as they extend backward.

10. *On the Embryology of Echinoderms;* by ALEXANDER AGASSIZ. 30 pp. 4*to*, with 4 plates. (From the Memoirs of the American Academy, vol. ix, 1864.)—The author takes up in this paper, in succession, the Echinoids, Ophiurans, and Holothurians, illustrates the development in species under each with detailed descriptions and figures, and then compares the results with what is already known of the development of our common star-fish, in order to trace out the agreement of the mode of formation of the young in these four subdivisions of Echinoderms. Mr. Agassiz concludes that, in each, the young in its earliest stage is in form an open spiral star. He says, respecting Müller's observations, that it is natural that his idea, that we have in the development of Echinoderms a passage from the bilateral to the radiated form, "should have made such a strong impression as to prevent his noticing the radiated character of the young embryo, hidden as it is by an external appearance of bilateral symmetry. And had it not been for the clear idea we now have of the character of the parts of radiated animals, (see L. Agassiz, Contrib. Nat. Hist. U. S., iii, iv,) I doubt not that Müller's view would have gained general acceptance among investigators; and the whole framework of classification, based upon the idea that a plan pervades the different types of the animal kingdom, would have fallen to the ground, if it could have been clearly proven that in Echinoderms we had a transition from one of these plans to another."

11. *On Dimorphism in the Hymenopterous genus Cynips*, with an appendix containing hints for a new classification of Cynipidæ and a list of Cynipidæ, including descriptions of several new species inhabiting the Oak-galls of Illinois; by BENJ. D. WALSH, M.A. 58 pp. 8vo. (From the Proceedings of the Entomological Society of Philadelphia, March, 1864, pp. 443–500.)—The Cynips studied by Mr. Walsh make galls on a species of Oak, the *Quercus tinctoria*. Part of these galls produce males and females of the *Cynips spongifica* in June. Another portion of them, of wholly similar general character, remain green till autumn, and produce in October and November, and also in the following spring, another form

of Cynips—the *Cynips aciculata*, hitherto regarded as a distinct species, all the individuals of which are *females*. Mr. Walsh appears to prove that the latter, although widely different in many characters, is only another form of the *C. spongifica*, and, thence, that this species is dimorphous. The individuals produced in June live but 6 or 8 days; what place in nature, then, the author asks, is filled by the *aciculata?* In reply, he suggests, from the analogy of *Apis*, *Bombus*, etc., that "the female *aciculata* generates galls which produce by parthenogenesis male *spongifica*, and that the females and males of the latter, coupling in June, oviposit in the same month, in the young buds of the oak, eggs that remain dormant till the following spring, some of which then produce *female spongifica* in June and some *female aciculata* in the autumn or early in the following spring, and these last, in their turn, generate *male spongifica* to appear in the following June." He continues, "It may also be the case that some few male *spongifica* are generated by female *spongifica*." The author next sustains this opinion by mentioning some of the analogies that have been observed in other Hymenopterous Insects.

12. *On the mineral secretions of Rhizopods and Sponges;* by G. C. Wallich. (Ann. and Mag. Nat. Hist., [3], xiii, 72.)—Mr. Wallich sustains the view of Prof. Max Schultze that the siliceous spicules found sometimes in the shells of Rhizopods are foreign to the Rhizopods, and a result of a sponge-growth within. He shows that the spicules of a sponge commence in vaccuoles in its sarcode-mass, and consist of successive layers of silica about a linear vaccuole as its axis, the layers being secreted at unequal rates on the inner and outer surfaces; and that no such mode of secretion is to be found in any Rhizopod. In the formation of the shell of a Rhizopod, the first layer of shell is deposited from the immediate surface of the sarcode-mass, and no further deposit takes place within; every subsequent addition is made from without, and takes place from a special layer of sarcode which is connected with the interior sarcode through the foramina, or in imperforate genera "probably by a reflexion of the sarcode-substance through the main aperture of the last-formed chamber, after the fashion of *Gromia*." This exterior layer of sarcode, which thickens and gives the markings and structure to the shell, he calls the *chitosarc* (from *χιτων a coat*). This same method of secretion he recognizes also in the *Polycystines*, the siliceous shell being an internal framework or skeleton formed by additions derived from an outer layer of sarcode. These siliceous secretions are solid throughout their thickness, the spines never being tubular. The same general fact is essentially true of the *Acanthometrina* and *Thalassicollidæ*. In the *Dictyochidæ*, however, which are intermediate between the last and sponges, the siliceous framework is tubular, and it is formed of two isometrical portions. The shells of *Globigerina* among Rhizopods and of *Haliomma* among Polycystines are stated to have often their chambers choked up with entozootic sponge-growth; whilst the chambers of *Globigerina* are at times filled with effete frustrules of a free-floating pelagic surface Diatom, namely, *Chætoceros*.

[The tendency to the growth of sponge tissue with its siliceous spicules may have some connection with the formation of Glauconite (green material of the green sand) in Rhizopod shells.]

13. *On the Law of the Production of the Sexes in Plants and Animals;* by Prof. THURY, of Geneva.[1]—Mr. Thury's memoir is divided into three parts. In the first, entitled "Deduction of the Law of the Sexes," the author indicates the course of ideas which has led him to his theory. The second, which is shorter, contains, under the title of "Résumé," the complete exposition of the author's notions. The third is a "Notice," prepared by Mr. Cornaz, in which this clever agriculturist describes the experiments which he has made, during two consecutive years, for the verification of the author's theory, and by which this theory appears to be completely confirmed.

The limits of this article do not allow of our following the author through the whole series of reasonings by which he establishes his theory. We shall only state that the study of plants, in which, by the management of the influence of external agents, the observer is enabled to instigate the development of either one or the other sex, seems to prove that the development of the male sex is always related to those general causes which induce a more complete maturation of the juices and a more perfect development of the organs. This fundamental fact the author applies to the animal kingdom. He refers, in the first place, to the fundamental identity of the two sexes—an identity which allows us to explain the characteristic differences of the sexes by simple differences in the mode and amount of development. He then seeks the causes of these differences, by analogy with plants, in the conditions which, at a certain moment (very near the first origin of the organism, since it is anterior to the determination of the sex), produce a more complete development in the case of a male, and a less advanced or less complete development in that of a female.

It remained to fix the precise moment at which this primary determination of the sex takes place. This might be *before* fecundation, or *during*, or *after*, this act. In the former case, if the fecundation were retarded, this retardation, permitting a more complete development of the ovum, must generally induce the production of male individuals. Now, in bees, according to the observations of Huber, if the fecundation take place early, workers (i. e. females) are chiefly produced; whilst, if the fecundation be retarded beyond the twenty-second day, all the eggs deposited are male eggs. According to Mr. Thury, the decisive moment for the production of the sex will therefore precede the act of fecundation.

It is true that in bees the interpretation of the facts is very complex, partly on account of parthenogenesis, partly in consequence of some other peculiar circumstances in the reproduction of these insects. But the author also knew, from some previous experiments, that, in domestic poultry, the eggs last laid nearly always furnish the cocks of the clutch; and he thought it probable that the last eggs which detach themselves from the ovary of the fowl are those which have had the most time for maturation. These eggs are fecundated, as all physiologists are aware, during their passage through the upper part of the oviduct. Therefore here also, when the fecundation is retarded, males are the result.

[1] Translated by W. S. Dallas, F.L.S., from the abstract by Prof. Pictet in the "Bibliothèque Universelle," September 20, 1863, p. 91, for the Ann. Mag. Nat. Hist., from which ([3], xiii, 68), it is here cited.

It was easy to apply the preceding data to the uniparous Mammalia. In these the ovum separates from the ovary at the commencement of the rutting season, and it may be fecundated at any time during the whole period that the female continues in heat, and consequently when its maturation or development is more or less advanced. If the fecundation take place at the commencement of the period of heat, a female is the result; if at the end of this period, a male. This is the conclusion which is fully justified by the experiments of Mr. Cornaz.

It is plain, according to the author, that the life of the unfecundated ovum is divisible into two periods. In the first of these it is in principle a female ovum, in the second a male ovum. The turning moment (*moment de vire*), according to the author, is the time (probably very short) which separates the two periods, and in which the natural course of development induces some sudden change, the nature of which histology should reveal to us. He assumes that the relative duration of the two periods of the life of the ovum may be modified under the influence of the organic state of the female, whence would result a predisposition on the part of some females to give birth either to individuals of their own sex or to males. Temperature, by its direct action on the ovum, and the influeuce of the fecundating male upon the organic condition of the female, would also produce similar results.

The author, in all his deductions, appears to start from a general point of view, which he certainly indicates, but nowhere demonstrates in a positive manner, regarding it apparently as a sort of axiom. He assumes that "*sexual life, being common to animals and plants, must be subjected to identical fundamental laws in both kingdoms.*" If this be true of the two kingdoms, it must apply with still more reason to the various divisions of the same kingdom. This admits of much generalization; but (and this is the difficulty) we have yet to distinguish with certainty the facts which bear upon essential laws from the infinitely varied manifestations by which these same laws are realized in combination.

The second and third parts of Mr. Thury's memoir are here reproduced entire.

Second Part—Summary and Practical Observations.—1. Sex depends on the degree of maturation of the ovum at the moment of its fecundation.

2. The ovum which has not attained a certain degree of maturation, if it be fecundated, produces a female; when this degree of maturation is passed, the ovum, if fecundated, produces a male.

3. When, at the rutting-season, a single ovum separates from the ovary to descend slowly through the genital canal (as in uniparous animals), it is sufficient that the fecundation takes place at the commencement of the rutting-season to produce females, and at the end to produce males—the turning-point of the ovum occurring normally during its passage in the genital canal.

4. When several ova separate successively from the ovary during a single generative period (multiparous and oviparous animals in general), the first ova are generally the least developed, and produce females; the last are more mature, and furnish males. But if it happens that a second generative period succeeds the first one, or if the external or organic conditions change considerably, the last ova may not attain to the superior degree of maturation, and may again furnish females.

Cæteris paribus, the application of the principle of sexuality is less easy in the case of multiparous animals.

5. In the application of the above principles to the larger Mammalia, it is necessary that the experimenter should first of all observe the course of the phenomena of heat in the very individual upon which he proposes to act, in order that he may know exactly the duration and the signs of the rutting-season, which frequently vary in different individuals.

6. It is evident that no certain result can be expected when the signs of heat are vague or equivocal. This is scarcely ever the case in animals living in a state of freedom; but cattle in the fattening-sheds or in the stable sometimes present this abnormal peculiarity. Such animals must be excluded from experimentation.

7. From the mode in which the law ruling the production of the sexes has been deduced, it results that this law must be general and apply to all organized beings,—that is to say, to plants, animals, and man.

It is necessary to distinguish carefully the law itself (1 and 2 of this summary), which is absolute, from the applications of it which may be made with more or less facility.

Third Part—Notice by Mr. George Cornaz.—I, the undersigned, George Cornaz, administrator of the estate of my father, the late M. A. Cornaz, President of the Agricultural Society of "La Suisse Romande," at Montet, in the Canton de Vaud, certify that I received from Mr. Thury, Professor in the Academy of Geneva, under date of the 18th February, 1861, some confidential instructions the object of which was an experimental verification of the law which governs the production of sex in animals.

I have applied to the management of my herd of cows the data furnished to me by Mr. Thury, and obtained *at once, without any uncertainty, all the expected results.*

In the first place, in *twenty-two* successive cases, I wished to obtain heifers; my cows were of the Schwitz breed, and my bull a pure Durham; the heifers were in demand amongst breeders, and the bulls were only sold to the butchers. I obtained the desired result in *all* cases.

Having subsequently purchased a cow of pure Durham breed, I desired to obtain from them a new bull, which might replace the one which I had bought at great cost, without waiting for the chance of the birth of a male. I operated in accordance with the directions of Prof. Thury, and the success again confirmed the truth of the process which had been communicated to me—a process the application of which is direct and very easy.

Besides my Durham bull, I obtained six other bulls, of a cross-breed between the Durham and Schwitz, which I intended for work: by selecting cows of the same color and size, I obtained very well-matched pairs of bulls.

My herd consists of forty cows of all ages.

To sum up, I have made in all twenty-nine experiments according to the new process, and all have given the desired product, male or female: I have had no case of non-success. All the experiments were made by myself, without the intervention of any other person.

I can consequently declare that I regard the method of Prof. Thury

as real and perfectly certain, hoping that he will soon be able to profit all breeders and agriculturists in general by a discovery which will regenerate the business of cattle-breeding. (Signed) G. CORNAZ.

Montet, Feb. 10, 1863.

14. *Catalogue of North American Butterflies;* by J. WM. WEIDEMEYER. 42 pp., 8vo. From the Proceedings of the Entomological Society, Philadelphia. Printed by the Society, 1864.—The species included in this carefully prepared Catalogue are those of the Diurnal Lepidoptera, and the names of all are embraced that are known, thus far, to inhabit the continent of North America from Panama to the Arctic. References to the more accessible works are given and also to some extent the synonymy.

IV. ASTRONOMY.

1. *Altitudes of Shooting Stars;* compiled by H. A. NEWTON. (Communicated for this Journal.)—The following table contains the computed altitudes, above the earth's surface, of certain shooting stars. It is believed that it includes nearly all those which have been published. Many of them are unreliable, and for all we may reasonably assume a large probable error. Yet taken together they have value in investigations in terrestrial physics, and they furnish a basis for important deductions respecting the shooting stars themselves. The observations in August and November last will furnish considerable additions to the table.

In the second and third columns are the dates of observations in local time. The apparent brightness of each shooting star is expressed by the symbol or figure in the fourth column. This indicates the planet, or the magnitude of the fixed star, that is equal in brilliancy to the shooting star. Two numbers in the same line indicate that the observers differed in their estimate. In the fifth column is the computed altitude above the earth's surface of the shooting star at its first appearance. The unit is the geographic mile, the sixtieth part of a degree. In the sixth column is the altitude of the shooting star at its disappearance.

In the next two columns are placed such altitudes as the observers, or computers, considered uncertain, and some others which for certain reasons seem especially unreliable. To the former class belong Nos. 2, 9, 16, 20, 35, 39, 40, 48, 56, 65, 73, 83, 95, 96, 102, 103, 106, 107, 110, 146, 176, 206, 219, 223, 228, and 292. There was a small parallax, or a large probable error, for Nos. 3, 50, 51, 60, 79, 88, 90, 91, 121, 123, 124, 154, 160, 196, 200, 217, and 218. The altitudes of Nos. 125, 128, 131, 135, 136, and 167, are very improbable from their magnitude. Other large altitudes, as well as many of the smaller ones, might perhaps with good reason be also transferred from the fifth and sixth, to the seventh and eighth columns.

The following are the books referred to in the last column.

Brandes, *Versuche die Entfernung, die Geschwindigkeit,* etc., 8vo, Hamburg, 1800.
Benzenberg, *Die Sternschnuppen sind Steine,* etc., 8vo, Bonn, 1834.
Brandes, *Unterhaltungen für Freunde der Phys. und Astr.,* 8vo, Leipzig, 1825.
Astronomischen Nachrichten, referred to by the letters *A. N.*
Coulvier Gravier, *Recherches sur les étoiles filantes,* 8vo, Paris, 1847.
Heis, *Die periodischen Sternschnuppen* etc., 4to, Cöln, 1849.
Schmidt, *Resultate aus Zehnjahrigen Beobach.* über *Sternsch,* etc., 8vo, Berlin, 1852.
Jahn, *Unterhaltungen im Gebiete der Astr., Geogr. und Meteor.,* 8vo, Leipzig.

Table of altitudes of Shooting Stars.

No.	Date of Obs.	Hour.	Mag.	1st alt.	2d alt.	1st alt.	2d alt.	Authority.
1.	1798, Sep. 11,	8.1	3		14			Brandes, *Versuche*, &c.
2.	"	9.5	1				20	"
3.	13,	9.4	1				132	"
4.	Oct. 6,	8.5	Small		6			"
5.	"	10.1	4		18			"
6.	9,	8.5	2		45			"
7.	"	9.3	1		35			"
8.	"	9.3	2		52			"
9.	"	9.9	3				88	"
10.	"	10.1	1–2		66			"
11.	"	10.8	2		52	21		"
12.	"	11.2	3		67			"
13.	14,	12.3	5		28			"
14.	"	13.6	3		43			"
15.	"	13.8	4		38			"
16.	Nov. 4,	8.9	3		43	20		"
17.	"	9.0	2		82			"
18.	"	9.3	1		92			"
19.	"	10.1	1–2	64	41			"
20.	"	13.8	1–1				44	"
21.	"	14.5	1	68	46			"
22.	1801, Sep. 15,		5	31	33			Benzenberg, *Ster.* &c. p. 16.
23.	Oct. 3,		4		28			"
24.	1802, Aug. 10,		5		15			"
25.	1823, May 2,	9.8	2	76	15			Brandes, *Unterhalt.* &c.
26.	"	10.7	2	59	50			"
27.	7,	10.1	4	6	6			"
28.	"	11.7	4–5	4				"
29.	10,	9.6	1	49	33			"
30.	Aug. 4,	10.8	Small	47	31			"
31.	10,	9.7	Small	31				"
32.	"	9.8	Small	36				"
33.	"	9.9	Small	25				"
34.	11,	9.7	3	119	135			"
35.	"	10.2				30	16	"
36.	"	10.5	1	67	32			"
37.	"	10.6	1	52	40			"
38.	"	10.8		41	27			"
39	"	11.0	4				28	"
40.	"	11.0	5				48	"
41.	"	11 0	2	108	57			"
42.	"	11.1	5	38	34			"
43.	29,	9.9	2		68			"
44.	30,	9.4	Small	43	55			"
45.	"	10.6	3–4	108	73			"
46.	Sep. 1,	9.2	5	49	51			"
47.	"	9.6	3	57	52			"
48.	"	9.7	1				64	"
49.	2,	9.3	3–4		12			"
50.	"	9.4	3			73	70	"
51.	"	9.7	1				22	"
52.	"	9.9	2–3		23			"
53.	"	9.9			34			"
54.	"	9.7	3	122	78			"
55.	"	10.2	3	19				"
56.	11,	9.5			21	16		"
57.	"	10.5		83	45			"
58.	12,	10.0	1–3	63	65			"
59.	27,	7.6	1–3	58	44			"
60.	"	7.8	4			104	128	"

No.	Date of Obs.	Hour.	Mag.	1st alt.	2d alt.	1st alt.	2d alt.	Authority.
61.	1823, Sep. 27,	7.8	4-5	59				Brandes, *Unterhalt.*, &c.
62.	"	8.0	3-4	55	45			"
63.	"	8.3	2-5		40			"
64.	"	8.6	3-4	56	47			"
65.	"	9.5	2-4				16	"
66.	Oct. 7,	8.2	3		45			"
67.	"	8.4	Large	79	57			"
68.	"	8.7	2-3	48	33			"
69.	"	8.8	4-5	35	25			"
70.	"	8.9	1-4	23	28			"
71.	"	8.9	1-4		34			"
72.	"	9.0	1-2	59	62			"
73.	"	9.2	2		81	260		"
74.	8,	7.6	Large	72	46			"
75.	"	8.3	4-5		55			"
76.	"	8.3			55			"
77.	"	8.5	4		22			"
78.	"	8.6	3	44	54			"
79.	"	8.6	3				540	"
80.	"	8.8	1-2	183	99			"
81.	"	8.8	3	8	10			"
82.	"	9.0	2-4	53	54			"
83.	"	9.2	Small				16	"
84.	"	9.3	2-3	52				"
85.	"	9.3	1-3	52	38			"
86.	9,	8.4	2-3	66	44			"
87.	"	8.6	5		53			"
88.	1825, Aug. 30,	9.0	1	83			261	Herther, *A. N.* xvii, 316.
89.	Sep. 1,	8.6	1	57	29			"
90.	9,	10.0	1		16	65		"
91.	17,	9.8	1	71			174	"
92.	Oct. 5,	10.3	2	47	29			"
93.	1833, Aug. 6,	10.3		29	33			Brandes (son), *A, N.* xvii, 17.
94.	7,	9.7			67			"
95.	"	9.8			44	14		"
96.	"	10.4					10	"
97.	9,	9.9				24	19	"
98.	"	9.9			65			"
99.	"	10.0			37			"
100.	"	10.0		49	35			"
101.	"	10.8			104			"
102.	"	10.8					26	"
103.	10,	9.3					32	"
104.	"	9.4			14			"
105.	"	9.5			86			"
106.	"	9.7				74	60	"
107.	"	10.1					8	"
108.	"	10.1			20			"
109.	"	10.2			8			"
110.	"	10.5					68	"
111.	"	10.7			4			" [343.
112.	Nov. 12,	17.8	Large	62	25			Twining, *Amer. Jour.*, xxvi,
113.	1834, Nov. 27,	10.5	Small	50	36			Loomis and Twining, *MS.*
114.	"	10.8		28	22			"
115.	Dec. 10,	16.7	3	67	44			"
116.	"	17.8	1	62	25			"
117.	1836, Nov. 11,			18	12			Boguslauski, *C. G.*, p. 91.
118.	"			61	36			"
119.	13,			41	12			"
120.	14,			53	66			"
121.	"	12.2	3			90	69	Erman, *A. N.*, xvii, 317.

No.	Date of Obs.	Hour.	Mag.	1st alt.	2d alt.	1st alt.	2d alt.	Authority.
122.	1836, Nov. 14,	12.3	3			197	184	Erman, *A. N.*, xvii, 317.
123.	"	13.3	1-2			21	21	"
124.	"	14.1	3			92	65	"
125.	1837, July 10,		3			247	171	Boguslauski, *C. G.*, p. 101.
126.	"		1	190	110			"
127.	"		1	31	15			"
128.	Aug. 10,	12.2	3			207	182	Petersen, *A. N.*, xvii, 318.
129.	"	12.2	1	164	138			"
130.	"	12.4	2	88	89			"
131.	"	12.6	4			1041	420	"
132.	"	12.7		123	75			"
133.	"	13.0	3	117	78			"
134.	"	13.3	1	184	100			"
135.	"	13.4	1			565	414	"
136.	"	13.8	1-2			200	323	"
137.	"	14.0	1	148	81			"
138.	"	14.1	2	65	45			"
139.	"	14.1	1	178	148			"
140.	"	14.3	1	151	166			"
141.	"	15.1	1	86	67			"
142.	"	13.4	3	115	115			"
143.	1838, Aug. 29,				38			Littrow, *C. G.*, p. 113.
144.	"			26	9			"
145.	"			86	52			"
146.	"				60	55		"
147.	"			55	28			"
148.	"			52	39			"
149.	"			26	29			"
150.	"			39	14			"
151.	"			52	24			"
152.	"			16	11			"
153.	"			27	12			"
154	1839, Aug. 10,	10.0		*		68	52	Erman and Petersen, *A.N.*,
155.	"	10.0	1-2			96	192	[xix, 28.
156.	"	10.1	♀	72	44			" "
157.	"	10 2	2	56	52			" "
158.	"	10.3	1	48	32			" "
159.	"	10 3	1	120	60			" "
160.	"	10 5	1			184	176	" "
161.	"	10.5	4	68	84			" "
162.	"	10.6	4	128	112			" "
163.	"	10.6	1	48	48			" "
164.	"	10.7	1	68	52			" "
165.	"	10.7	1			176	160	" "
166.	"	11.0	3	40	36			" "
167.	"	11.2	1			292	264	" "
168.	1842, Aug. 9,	9.7	2	68	52			Heis, *Per. Sternsch.*, p. 35.
169.	"	10.4	1	44	28			"
170.	11,	10.2	2	76	44			"
171.	"	11.4	1	80	64			"
172.	1845, Aug. 24,		2	19	13			Coul. Grav., p. 179.
173.	25,		4-5	54	54			"
174.	31,		4-5	43	39			"
175.	"		3	26	28			"
176.	"		4			28	12	"
177.	Sep. 1,		4	15	15			"
178.	"		4	15	15			"
179.	2,		6	13	15			"
180.	"		5	32	32			"
181.	"		5-6	22	21			"
182.	3,		2-3	35	35			"

No.	Date of Obs.	Hour.	Mag.	1st alt.	2d alt.	1st alt.	2d alt.	Authority.
183.	1847, Aug. 10,	9.5			64			Weyer, *A. N.*, xxvi, 212.
184.	"	10.9			48			"
185.	"	11.0			72			"
186.	"	11.7			40			"
187.	"	11.7			40			"
188.	"	11.7			36			"
189.	"	11.7			40			"
190.	"	11.7			40			"
191.	"	11.9			32			"
192.	"	11.9			60			"
193.	"	10.6			56			"
194.	"	11.3			28			"
195.	"	11.4			44			"
196.	1848, July 29,	10.0	Large		28	104		Schmidt, *A. N.*, xxvii, 370.
197.	Aug. 10,	9.7	1	38	26			Heis, *Per. Sternsch*, p. 35.
198.	1849, July 28,			48	38			Schmidt, *Resultate*, p. 142.
199.	29,	11.2	1	37	40			" p. 123.
200.	"	11.4	1	69			98	" "
201.	Aug. 10,		Large	80	18			" p. 142.
202.	11,	9.7	2	178	66			" p. 124 ff.
203.	"	10.2	1	84	70			" "
204.	"	10.9	3	41	19			" "
205.	"	11.1	2	96	74			" "
206.	"	11.6	4	44	39			" "
207.	"	11.9	4			496	272	" "
208.	"	11.4	2	72	76			" "
209.	"	12.1	3	49	38			" "
210.	"	10.1		61	54			" "
211.	"	9.8		31	41			" "
212.	"	9.7		35	68			" "
213.	20,	9.4	3	56	40			" "
214.	Sep. 27,	8.6	2	20	16			" "
215.	Oct. 22,	10.2	3	124	69			" "
216.	Nov. 11,	7.2	Large	52	45			" "
217.	"	7.7	2	35			115	" "
218.	"	7.5	4		12	78		" "
219.	12,	6.9	2			215	31	" "
220.	"	7.4		13	4			" "
221.	"	7.4	3	36	54			" "
222.	"	9.1	5	40	24			" "
223.	"	9.4	3			2	7	" "
224.	"	11.7	2	19	14			" "
225.	"	12.0	4	6	5			" "
226.	"	12.1	3	4	4			" "
227.	13,	9.4		52	46			" "
228.	19,	7.5	Large			156	116	" "
229.	1850, Aug. 10,	10.1		47	60			" "
230.	"	11.8	Large	80	56			" p. 142.
231.	1853, Aug. 9,	10.1	3-4		20			Heis, *Unterhalt.*, viii, 15.
232.	"	10.6	1-2	98	90			"
233.	"	11.4	2	92	85			"
234.	10,	10.4	1	32	27			"
235.	"	10.7	2	41	34			"
236.	"	10.8	1-2	52	53			"
237.	"	11.1	1	43	30			"
238.	"	11.1	1	24	23			"
239.	11,	10.9	1	19	15			"
240.	1856, Aug. 9,			19	5			Le Verrier, *Unterhalt.*, xi, 254.
241.	"			19	14			"
242.	"			17	11			"
243.	"			20	3			"

No.	Date of Obs.	Hour.	Mag.	1st alt.	2d alt.	1st alt.	2d alt.	Authority.
244.	1856, Aug. 9,			45	39			Le Verrier, *Unterhalt.*, xi, 254.
245.	"			64	36			"
246.	1858, Aug. 8,	9.4	1	46	29			Heis, *A. N.*, l, 148.
247.	"	10.5	1-4	128	62			"
248.	"	9.6	♀-2	67	29			"
249.	"	11.0	1-2	186	108			"
250.	10,	9.0	♀-1	216	40			"
251.	"	9.8	1-2	22	19			"
252.	"	10.0	♀-1		42			"
253.	"	10.0	2-3	48	42			"
254.	"	10.1	2-3	70	64			"
255.	"	10.4	1	108	78			"
256.	"	10.3	1	66	44			"
257.	"	10.3	1	60	48			"
258.	"	10 5	1-2	46	32			"
259.	"	10.5	1-2	62	42			"
260.	"	10.8	1	84	52			"
261.	"	10.7	1	78	48			"
262.	"	11.1	♀-2	88	48			"
263.	"	11.4	1-2	62	58			"
264.	"	11.6	2	36	34			"
265.	"	11.7	1	58	58			"
266.	11,	10.2	1		32			"
267.	"	10.8	1-2	52	52			"
268.	"	10.8	1	60	48			"
269.	"	11.5	1	72	60			"
270.	"	9 6	2	32	20			"
271.	"	9.8	2		32			"
272.	12,	10.8	1-2	48	35			"
273.	"	10.6	1-2	45	27			"
274.	"	10.9	1-2	82	72			"
275.	"	11.6	♀-1	108				"
276.	"	10.3	2-3	96	60			"
277.	"	11.8	3		44			"
278.	1861, July 16,	10.2	Large	148	38			*Brit. Assoc. Rep.*, 1862, 76 ff.
279.	"	11.5	Large	168	56			"
280.	Aug. 6,	11.4	♀	109	18			"
281.	8,	10.5	2		58			"
282.	"	10.6	1		43			"
283.	10,	10.5	1		40			"
284.	"	10.8	3		60			"
285.	"	11.5	Large	60	46			*Amer. Jour.*, [2], xxxii, 449.
286.	11,	10.3	♀	38	18			Herschel, and *Brit. As. Rep.*
287	Nov. 12,	5.8	Large	83	17			*Brit. Assoc. Rep.*, 1862, 78 ff.
288.	19,	9.6	Large	47	26			"
289.	1862, Jan. 28,	11.1	1-3	39	41			"
290.	Feb. 2,	8.3	Large	165	13			"
291.	23,	9 4	Large	35	17			"
292.	Nov. 13,	16.5	Large		27	41		*Amer. Jour.*, [2], xxxv, 147.
293.	1863, Aug. 9,	9.9	1	74	50			Herschel, *Proc. Br. Met. Soc.*,
294.	"	10.3	1	65	38			" " [ii, 19.
295.	10,	9.4	♅	62	46			" "
296.	"	9.6	♅	98	63			" "
297.	"	9.8	♀	48	22			" "
298.	"	9.9	2	75	73			" "
299.	"	9.9	2	61	45			" "
300.	"	10.1	1	48	36			" "
301.	"	10.1	1	113	57			" "
302.	"	10.1	1	54	46			" "
303.	"	10.2	1	94	54			" "
304.	"	10.2	1	105	48			" "
305.	"	10.3	1	68	50			" "

No.	Date of Obs.	Hour.	Mag.	1st alt.	2d alt.	1st alt.	2d alt.	Authority.
306.	1863, Aug. 10,	10.6	2	55	46			Herschel, *Proc. Br. Met. Soc.*,
307.	"	10.7	2	62	52			" " [ii, 19.
308.	"	10.7	2	73	72			" "
309.	"	10.8	♀	74	59			" "
310.	"	10.9	1	66	61			" "
311.	"	11.1	1	54	30			" "
312.	"	11.2	1	74	56			" "
313.	"			105	64			Heis, Ibid., p. 21.
314.	"			57	55			" "
315.	"			34	31			" "
316.	"			72	48			" "
317.	"			74	68			" "
318.	"			64	22			" "
319.	"			55	20			" "
320.	"			60	45			" "
321.	"			88	36			" "
322.	"			49	42			" "
323.	"			86	41			" "
324.	"			54	47			" "
325.	"			30	25			" "
326.	"			49	38			" "
327.	"			28	20			" "
328.	"			43	30			" "
329.	"			69	45			" "
330.	"			58	46			" "
331.	"			86	50			" "
332.	"			64	48			" "
333.	"			156	55			" "
334.	"			84	66			" "
335.	"			40	20			" "
336.	"			42	32			" "
337.	"			70	38			" "
338.	"			102	37			" "
339.	"			61	48			" "
340.	"			40	36			" "
341.	Nov. 13,	9.5	1	49	42			*Amer. Jour.* [2], xxxvii, 143.
342.	"	9.7	1	56	26			" "

The altitudes Nos. 231–239 were computed from the observations. A part of those from No. 25 to No. 87, are taken from Feldt's article, *Astr. Nach.*, xvi, 339. A few numbers in the sixth column represent the height of the middle point of the path, as Nos. 281–284.

The altitudes Nos. 313–340 are taken from a diagram given by Herschel in the *Proceedings of the British Meteorological Society.* I have not seen the printed results of Prof. Heis's observations. But as the series is very much more reliable than most of those in the table, I have ventured to add it to the rest, although the numbers are liable to considerable error in the two processes, of engraving, and of measuring from the diagram.

2. *On Sun-Spots and their Connexion with Planetary Configurations;* by BALFOUR STEWART, Esq., Observatory, Kew. (Proceedings of Royal Society.)—The author was led to investigate the solar autographs taken at Kew and Cranford, under the superintendence of Mr. Warren De La Rue, with the view of ascertaining if the behavior of sun-spots has any reference to planetary configuration. The following law was found to hold:—If the sun's disc be full of spots at any time, and if one of these begins to wane as it comes up by means of the sun's rotation to a

certain elliptical longitude, another will do the same. In fine, all spots at the same time behave in the same manner as they pass the same longitude. The author then remarked that, although this mode of investigation can only be considered as approximate, yet it furnishes us with an extremely delicate test of the *fact* of planetary action; for, if it be once clearly proved that sun-spots behave in this way, the only possible explanation is an influence from without. It was then shown that the influence of the planet Venus appears in this respect to be particularly powerful, the law being that, as any portion of the sun's disc recedes from the neighborhood of Venus, it acquires a tendency to break out into spots, while, as it approaches Venus, these spots begin to heal up. The author then referred to Mr. Carrington's observations on sun-spots, which appeared to indicate that the period when Jupiter is farthest from the sun is most favorable for the development of spots over all portions of the sun's disc, more or less (the sun's diameter being here small compared to the distance of the planet). Coupling this with the observation regarding Venus, it may perhaps be inferred that the approach of a planet to its primary is favorable to luminosity, while the secession of the planet is favorable to spot production. Proceeding now to variable stars, the best formal explanation of the phenomena there presented is given by that hypothesis which supposes the star to be partly dark and partly bright, and to rotate on its axis, presenting to us the dark and bright portions alternately; but this is physically improbable. If, however, we suppose a large planet to revolve near the star, we shall have, if the above law holds true, a bright part next the planet and a dark part farthest from it; and this appearance will revolve with the planet, and will be phenomenally equivalent to a body partly dark and partly bright. Again, if a large planet have a very elliptical orbit, there will be a long space of time during which the former is far removed from its primary, and a short space during which it is very near; and, if we assume the law stated above, we should here have a long time of comparative darkness and a short time of intense brightness. Such an alternative is presented to us by temporary stars. On the whole, therefore, this law seems to explain all that is yet known on this subject, and may, perhaps, be of use as a temporary hypothesis.—*Reader, April* 23, 1864.

3. *Observations on the Spots on the Sun from Nov.* 9, 1853, *to March* 24, 1861, *made at Redhill;* by R. C. Carrington, F.R.S. With 166 plates. London: Williams & Norgate.—The following is from a notice of this great work (signed J. N. L.) in the Reader of May 7:—[A copy of the work has not yet reached us.—Eds.]

All our text-books tell us that the Sun turns on its axis, the period of his axial rotation having been deduced from observations of his spots. But, from the time of Galileo, who made the period of rotation about a lunar month, down to our own, authorities have differed very considerably. Thus Grant, in his "History of Physical Astronomy," gives a period of $27^d\ 8^h$ (he quotes no authority). Laugier found $25{\cdot}34^d$, and later observers have made it still less.

Mr. Carrington now comes to the rescue, and tells us that *the spots travel at different rates, depending upon their distance from the equator* either north or south, and that the different rates are bound together by a law, so

that he is enabled to represent all the rates very nearly by the formula: $865 - 165' \sin \frac{1}{4}$ lat.

Consequently the sidereal rotation of the equatorial photosphere is accomplished in 30·86 days, and of that at a latitude of 50° N. or S.—the highest point at which spots have been observed—in 28·36 days.

We said of the *photosphere:* the Sun itself—whether it be the glade-bedeckt world imagined by Sir Wm. Herschel, or the incandescent globe required by both the old and the new philosophies—has revealed none of its secrets to Mr. Carrington. But it is clear that *it* must be content with one only of these differing rates of motion; and the question is, which is it? Sir John Herschel, in an admirable article on sun-spots, in the last number of the *Quarterly Journal of Science*, deals with this question. Mr. Carrington considers that the views of Professor Thomson "on the Mechanical Energies of the Solar System" are supported by his discovery, supposing that the Sun itself travels more slowly than the equatorial photosphere. He remarks;—"In the absence of an impressed motion from some such external force, it would be expected that the currents of the surface of the Sun would resemble those of the Earth's ocean and atmosphere, and be westerly and toward the poles in the tropical latitudes, and easterly in the higher latitudes; the direction of rotation in such cases being the same, and the equatorial region in each the hottest."

Besides determining anew the elements of the Sun's equator—in other words, the position of the Sun's pole-star—Mr. Carrington has put us in possession of an important fact regarding the minimum period of sun-spots. He detected "a great contraction of the limiting parallels between which spots were found previously to the minimum, . . . and soon after this epoch the apparent commencement of two fresh belts of spots in *high latitudes*, north and south, which have in the subsequent years shown a tendency to coalesce, and ultimately to contract, as before, to extinction."

In Sir John Herschel's paper, to which we have before alluded, there is a passage which shows in a very strong light the value of these remarks of Mr. Carrington. In attempting to account for the phenomena of sun-spots by the presence of a nebulous ring, he writes:—

"Let us suppose (and such a supposition has not been deemed inadmissible in attempting to account for the periodical return of meteors) the existence of an elliptic ring of vaporous, nebulous, or small planetary, matter, with such a major semi-axis (4·979) as corresponds to a periodic time of each of its particles = 11·11 years; of such eccentricity as to bring its perihelion within the limits of the solar envelopes; and revolving either in the plane of the ecliptic or in some other plane at a more considerable inclination of the sun's equator. Let it be further assumed (still in analogy with assumptions not regarded as unreasonable in the meteoriferous ring), that the distribution of the circulating matter in it is not uniform—that it has a maximum and minimum of density at nearly, but not quite, opposite points, and no great regularity of gradation between them. It is very conceivable that the matter of such a ring, introducing itself with planetary velocity into the upper and rarer regions of the sun's atmosphere at an incidence oblique to its regular and uniform equatorial drift, might create such disturbances as, either acting di-

rectly on the photosphere, or intermediately through a series of vortices or irregular movements propagated through the general atmosphere, should break its continuity and give rise to spots, conforming in respect of their abundance and magnitude to the required law of periodic recurrence. If the change of density from the maximum to the minimum were gradual, but from the minimum to the maximum more abrupt, so as to allow the disturbances to subside gradually and recommence abruptly—the fresh and violent impulse would be delivered first of all on a region remote from the equator (by reason of the obliquity of the ring), and would give rise to a recommencement of the spots in comparatively high latitudes.

If the section of such a ring as we have supposed at its aphelion were *nil*, the period of 11·11 years would be strictly carried out; the maxima and minima would succeed each other with perfect regularity, and the paucity and abundance of the spots in the several phases of the same period would follow a fixed ratio. But if not, the several parts of the ring would not revolve in precisely equal times—the period of 11·11 years would be that of some dominant medial line, or common axis of all the sections in which a considerable majority of its matter was contained—and the want of perfect coincidence of the other revolutions would more or less confuse without obliterating the law of periodicity, which, supposing the difference to be comprised within narrow limits, might still stand out very prominently. Now, it might happen that there were two such medial lines, or more copiously stocked ellipses, each having a maximum or minimum of density, and that their difference of periodic times should be such as to bring round a conjunction of their maxima in 56 or any other considerable number of years; and thus would arise a phenomenon the exact parallel of Dr. Wolf's long period and his series of greater and lesser maxima."

We have given this extract to show the value of a *single well-ascertained fact;* and we congratulate our author upon the possession of that sagacity which, by limiting his field, has enabled him to produce such facts.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Medal of the Royal Society to Prof. William Thomson.*—At the meeting of the Royal Society of April 18th last, the Keith medal was presented to Prof. Wm. Thomson, with the following remarks by Sir David Brewster, Vice-President of the Society and Chairman of the meeting:—"Professor William Thomson, who was elected a Fellow of the Society in 1847, has, during the last seventeen years, communicated many valuable papers to the Society which have added greatly to the value of its transactions. These papers, and others elsewhere published, relate principally to the theories of electricity, magnetism, and heat, and evince a genius for the mathematical treatment of physical questions which has not been surpassed, if equalled, by that of any living philosopher. In studying the mathematical theory of electricity he has greatly extended the general theorems demonstrated by our distinguished countryman, Mr. Green, and was led to the principle of 'electrical images,' by which he was enabled to solve many problems respecting the distribution of electricity in conductors, which had been regarded as insolvable by the

most eminent mathematicians in Europe. In his researches on thermodynamics, Professor Thomson has been equally successful. In his paper 'On the Dynamical Theory of Heat,' published in our *Transactions* for 1851, he has applied the fundamental propositions of the theory to bodies of all kinds, and he has deduced many curious and important results regarding the specific heats of bodies, which have been completely verified by the accurate experiments of Mr. Joule. No less important are Professor Thomson's researches on solar heat contained in his remarkable paper 'On the Mechanical Energy of the Solar System'—his researches on the conservation of energy as applied to organic as well as inorganic processes; and his fine theory of the dissipation of energy, as given in his paper 'On a Universal Tendency in Nature to the Dissipation of Mechanical Energy.' To these we may add his complete theory of diamagnetic action, and his investigations relative to the secular cooling of our globe, and the influence of internal heat upon the temperature of its surface. The value of labors like these could not escape the notice of the Council of this Society, and they would have entitled their author to the Keith Prize had they not been presented to the Society when the prize was devoted to other branches of science. It is not, therefore, for these researches and discoveries that the Keith Medal has been awarded to Professor Thomson, but for the very interesting and important discovery in abstract dynamics which he has communicated to the Society during the biennial period appropriated to physical sciences. In presenting this prize to Professor Thomson, I am proud to think, and I am sure that all here will participate in the sentiment, that Scottish science has such a representative in the University of the west, while, in our own, it has one of kindred genius and power."—*Reader*, April 23, 1864.

2. *Sir R. I. Murchison.*—The Wollaston Gold Medal was awarded to Sir R. I. Murchison by the Geological Society, at its annual meeting in February last, for his "distinguished services in Paleozoic Geology, especially (1) for his great work entitled the Silurian system, (2) his work on the Geology of Russia, and (3) for his discovery of the true relations of all the rocks beneath the Old Red Sandstone that form the Highlands of Scotland."—*Reader*, March 5.

3. *Man formerly accompanied by the Reindeer in Central France.*—Lartet and Christy have found in caves in central France (that of Eyzies and others) a floor-breccia containing bones of the Reindeer and other animals, ashes, fragments of charcoal, flint chippings, and weapons and utensils of Reindeer bones and horns, with slabs of stone having sometimes the forms of animals scratched upon them. Among the remains of the Reindeer, several vertebræ are sometimes found united, and also jointed bones with their parts still in connection, showing that the animals must have lived in the region; and the long bones are usually broken in the same uniform way, and evidently to get the marrow out. The remains of the common stag, wild boar and hare are very rare. A few teeth of the Irish Elk (*Megaceros Hibernicus*) are found, and an occasional dental plate of the old Elephant (*E. primigenius*) is met with. There is no written record of the existence of the Reindeer, or of a subarctic climate, in what is now temperate Europe.—*Nouv. Obs. de MM. Lartet et Christy, etc.*, *Comptes Rend.*, lviii, Feb. 29, 1864.

4. *Extracts from a paper on the Geography of British Columbia and the Condition of the Cariboo Gold District;* by Lieut. H. S. Palmer, R.E.—Lieut. Palmer mentioned that since the first discovery of gold in British Columbia in 1858, fresh deposits had gradually been traced farther and farther northward, till ultimately the well-known fields of Cariboo had been reached, 500 miles from the mouth of the Fraser. Entrusted with the task of a general survey, he details the geographical outline of the colony, the seaboard of which extends 500 miles, protected throughout almost its entire length by Vancouver and Queen Charlotte islands. This seaboard is indented in the most extraordinary manner by deep bays and arms of the sea, presenting an extent of sheltered inland navigation, and an actual length of shore-line, such as are nowhere equalled on any similar stretch of coast in the world.

The most marked physical feature of the country, viewing it from the shore inland, is the parallelism of two mountain ranges with an elevated intervening plateau of rolling country 100 miles in breadth. The coast-line of mountains is known as the Cascade or Coast range, 120 miles wide, the western slopes of which are covered with the most magnificent forest. Its sea-front is everywhere bluff and abrupt and quite close to the shore, except where the Fraser falls into the San Juan Fuca Sound, when it recedes some 40 miles. The eastern side of the range is drier, the trees more scattered, and the general profile less abrupt. The principal crest of this chain is about 5000 feet above the sea, a peculiar characteristic being the almost entire absence of peaks. The rivers on the east side are naturally longer and less impetuous than those on the west; but occasionally some of them rise on the plateau, and thread the mountains till they fall into the sounds. Above some of these, glaciers are said to have been seen; but nothing authentic seems to be known on this subject.

The scenery of the table-land, which is well suited for pastoral purposes, is described in high terms; the rivers having occasionally hollowed out for themselves channels of immense depth, in which occur splendid cascades, some of which are mere fissures; in other cases running through broad-terraced valleys, or in vales of gently undulating slopes covered with grass and picturesquely dotted with yellow pines. Here and there are pretty sheets of water, which, like the rivers, are well supplied with numerous kinds of fresh-water fish. Above 3000 feet, the grass, which gradually gets less nutritive with the increased elevation, gives place to a universal mantle of dwarf fir. Here farming has proved moderately successful at an elevation of 2100 feet, but Lieut. Palmer doubts whether a considerable time must not elapse ere enough grain can be raised in the more sheltered and well-irrigated valleys, to admit of its finding a market at the mines or settlements.

Just beyond begins the second mountainous range, which extends without a break to the watershed of the Rocky Mountains, which as far north as the Peace river, flowing eastward, forms the eastern boundary of the colony on this side. The only portion of this unexplored region where white men are to be met, is Cariboo.

Cariboo lies in the elbow formed by the upper waters of the Fraser, and is bounded on the south by the Quesnelle river. A marked phe-

nomenon is the confused congeries of hills of considerable altitude, from 6000 to 7000 feet high, thickly timbered, whence subordinate ranges radiate as centres. Each valley thus formed is the bed of a stream of more or less proportions, from the tiniest, called 'gulches' by the miners, which may be jumped over, to respectable-sized rivers. All these have long since been 'prospected,' every creek having been discovered to be more or less the site of the richest deposits of gold. A circle of three miles radius from the top of Bald mountain contains five creeks, two of which are the most notorious gold-beds in the colony. Snowshoe mountain contains the headwaters of no fewer than six of these within a similar area, the streams in every case radiating to every point of the periphery. The views from the summits of these mountains are described as splendid.

A succession of auriferous deposits have been traced, following the general trend of the main chain of mountains extending from the southern boundary of the colony to the Peace river, i. e., over 7° of latitude, while the extremities, so far as ascertained, lie between the meridians of 119° and 122° W.

The winter of Cariboo appears to be much more severe and prolonged than that of the coast, or of Vancouver Island, and will much retard the development of the mines, which are accordingly during that season 'laid over,' as it is termed—i. e., the laws enforcing the mode of working them, &c., are remitted for the time. The thermometer sometimes falls to −35° C. (31° below zero of Fahr.), when of course nothing but underground claims can be worked. The thaw, which commences about April, renders Cariboo for a season anything but an enviable residence, owing to the rains and the steaming mists, while locomotion is all but impossible. In past years the trail at this season has been loathsome from the numbers of horses that lay unburied after succumbing to the tremendous toil of conveying the first convoys of provisions.

Although for ten or eleven months in the year the country has a gloomy, cheerless aspect, August and September being the only bright exceptions, it is remarkably healthy. The sun is late in making his appearance, even in midsummer, owing to the hills enclosing the diggings on every side.

Of late 400 miles of excellent waggon-roads lead from Yale, the present head of steam-navigation, so that the entire distance from New Westminster to Cariboo can now be accomplished in from six to seven days. The author, in summing up, said that at the estuary of the Fraser, the winters somewhat resembled those of England, though the extremes were greater; and that the rainfall there is about 54 inches annually.—*Proc. Roy. Geogr. Soc.*, March 14th, viii, 87.

5. *A newly discovered pass across the Andes.*—Señor Cox, the son of an English physician at Valparaiso, has discovered a pass across the Andes, not over 2800 feet high in its most elevated part. He started in 1862 from Port Montt, a new German settlement now containing 15,000 inhabitants, near the island of Chiloe, and proceeded by way of the two lakes Llanquilhue and Todos os-Santos, and crossed over the pass to the almost unknown inland sea of Nagel-huapi (Lake of Tigers), on the eastern side of the Andes.—*Proc. Roy. Geogr. Soc.*, May 9.

6. *Violet colors from iodine.*—Prof. HOFMANN has patented in England the process of manufacturing a new color, obtained from iodine, which affords several beautiful varieties of violet. The material, which is to be used for dying, is made by mixing rosaline with the iodids of ethyl, methyl or amyl.—*Athenæum*, Ap. 2.

7. *The Holy Land and Dead Sea.*—An expedition from France conducted and equipped by Duc de Luynes, and having L. Lartet, as its geologist, is now in the region of the Holy Land and Dead Sea, engaged in investigations bearing on unsolved problems connected with that part of Western Asia. According to a brief report made by Daubrée to the Academy of Sciences at the last meeting in March, cave deposits abounding in flint knives and fossil bones were found soon after landing at Beyrout. It is reported also that Mr. Vougouë has discovered flint knives in a cave at Bethlehem, and also on Mt. Sinai; and that the former locality will no doubt be examined by the Duc de Luynes's expedition.—*Reader*, April 2.

8. *Bone-Cave in Borneo.*—A bone-cave has been stated to occur in Northwestern Borneo, containing numerous bones in the hardened guano which constitutes its floor; but none of the bones have yet been collected or examined.

9. *Heights in the Rocky Mountains.*—Pike's Peak, according to observations by C. C. Parry, in July, 1862, has an elevation of 14,215 feet, and Mt. Gray, on the upper waters of South Clear Creek, of 14,245 feet. Mr. Parry remarks that the observations in both these cases were made under unusually favorable circumstances, and are believed to furnish accurate results.—*C. C. Parry, in the Daily Rocky Mountain News, for March* 13, 1863, *Denver, Colorado Ter.*

10. *Astronomy in France.*—A proposition has emanated from Le Verrier for the establishment of a comprehensive Astronomical and Meteorological Association, the head office to be in the Imperial Observatory. The Association, the plan of which has been approved by the Emperor, will be under the direction of Le Verrier.—*Athenæum*, *May* 28.

11. *Law for the primary and secondary barometrical maxima and minima in each half-month.*—Mr. PLINY EARLE CHASE, of Philadelphia, announces in a letter dated June 4th, that on the 17th he will read before the Philosophical Society a paper sustaining his law for the primary and secondary barometrical maxima and minima in each half-month by showing its precise correspondence with the St. Helena three years' hourly observations in four-fifths of the averages, and that in the remaining fifth, the greatest deviation is one day.

12. *Chicago Observatory.*—An astronomical observatory has been recently commenced at Chicago, through the liberality of some of her citizens, to be connected with the University of Chicago. A large equatorial telescope, now partly finished, has been ordered from Alvan Clarke, of Boston, which is to be 23 feet in length, and 18¾ in aperture. It is to cost, including transportation and mounting, $18,187, and to be finished in June, or some time before the tower is ready for its reception. The tower is to be octagonal in shape, 35 feet in diameter and 100 feet high to the hemispherical top. Another tower, also, is to be erected, for the meridian circle.—*Chicago Tribune*, Feb. 23, 1864.

OBITUARY.

RUDOLPH WAGNER.—The eminent comparative anatomist, R. Wagner, died at Göttingen on the 13th of May. He was born at Baireuth in 1805. He studied at Erlangen and Würtzburg, and afterwards at Paris; in 1833 he became Professor of Zoology at Erlangen, and in 1840, of Comparative Anatomy at Göttingen. In 1834 he published his *Lehrbuch der vergleichenden Anatomie*, in 1839, his *Lehrbuch der Physiologie*, and in 1854, his *Neurologische Untersuchungen*, embracing the results of his investigations on the electrical organs of the torpedo, made in Italy in 1845, 1846, and of other researches. He also contributed to the *Handwörterbuch der Physiologie*, of which he was editor, and to various scientific Journals.

EVAN PUGH, Ph.D., President of the Agricultural College of Pennsylvania, died April 29th, 1864. [An obituary notice will appear in our next number.—EDS.]

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Metallurgy: The art of extracting metals from their ores, and adapting them to various purposes of manufacture;* by JOHN PERCY, M.D., F.R.S., Lecturer on Metallurgy at the Royal School of Mines. *Part II: Iron and Steel.* 8vo, pp. 934. Murray, London, 1864.—This volume forms the second division of Dr. Percy's great work on Metallurgy, already briefly noticed in a former number of this Journal.[1] Although its issue from the press has been deferred for more than a year after it was promised, this delay has been greatly to the advantage of the work, for we have now given us one volume devoted entirely to *Iron and Steel.* It is characterized by the same thoroughness, fairness, and comprehensiveness which we noticed in speaking of the first volume. It is copiously illustrated with drawings, chiefly from original sources, and carefully laid down to scale. It also contains the results of a large number of original investigations, having an important bearing on many of the practical and theoretical points discussed, and constituting one of the most interesting and valuable features of the work. The author has had the coöperation of some of the leading Ironmasters and Metallurgists in Great Britain and on the Continent, in many matters regarding special processes and furnaces. Prof. J. P. Lesley has furnished information and statistics of iron-smelting in this country, and we are glad to notice two large folio lithographs of the Thomas Anthracite Iron Furnaces at Hokendauqua, Pa., from drawings made under the direction of Samuel Thomas, Esq.

It is scarcely possibly within our limits to give even a brief synopsis of the work. The first 146 pages are devoted to the *physical and chemical properties of iron*, then 50 pages of matter on the *alloys of iron*, and this is followed by a description of the *ores of iron*, their *chemical composition* and the methods for their *assay*,—in all some 55 pages. Dr. Percy then gives about a hundred pages to the discussion of the methods for the *indirect extraction of iron in the malleable state from the ore*, in which he makes mention of many interesting historical facts of the simple processes for iron-smelting used by the natives of India, Burma, Borneo, Africa and Madagascar; including also long no-

[1] [2], xxxv, 118.

tices of the *Catalan Process* and the *German Hearth*, of great interest from their extensive application in some parts of our country. Under the *indirect extraction of iron in the state of cast-iron from the ore*, we have a full account of the chemical phenomena of the blast-furnace, a description of the blast-furnaces used in different countries; a discussion of the "hot-blast" and of the "waste gases"; the form of the blast-furnace; the character and composition of the pig-iron produced, etc., occupying over 200 pages. In the chapter *on the production of malleable iron from cast-iron*, are given all the details in regard to *fineries* and *hearths*, and the *puddling process*, with remarks on special qualities of iron, and interesting commercial details. The section on *Steel* is equally comprehensive. In conclusion, there is given an exceedingly interesting *sketch of the history of iron*. The whole book is full of valuable observations and criticisms: the latter, though sometimes bordering on the personal, are alike entertaining and instructive. It is not only the greatest work on Iron and Steel in the English language, but it is also one of the most original, comprehensive and extensive practical works ever published on these subjects. G. J. B.

2. *Annual Report of the Board of Regents of the Smithsonian Institution for the year* 1862. Washington, 1863.—Forty-five pages of this volume are occupied by the Report of the Secretary, Prof. Henry, which shows that the Institution is doing a large amount of excellent work "for the increase and diffusion of knowledge," in the way of the promotion of scientific researches and explorations, the increase of its Museum, the distribution of specimens to American Institutions, the publications of new memoirs or works, and the sustaining of a system of lectures at Washington. The lectures of the year are in many cases printed in the Annual Report, and add greatly to its value. The volume for 1862 contains the Lectures of Pres. F. A. P. Barnard on the Undulatory Theory of Light, pp. 107–239; and of Prof. Daniel Wilson, of Toronto, on Physical Ethnology, pp. 240–302. And in addition there are the following foreign and American selected memoirs: A. Morlot's introductory lecture on the study of high antiquity, delivered at the Academy of Lausanne, Switzerland, Nov. 29, 1860; a memoir by J. Lubbock, Esq., on North American Archeology; Flourens's Historical Sketch of the Academy of Sciences of Paris, and also his Memoirs of von Buch and Thenard; Quatrefages's Memoir of I. Geoffroy Saint Hilaire; a translation of a paper by T. L. Phipson on the Catalytic Force, or Studies of the Phenomena of Contact; views by J. P. Lesley on the Classification of Books; and a Catalogue of Prize Questions of Scientific Societies. The volume also contains an account of a female mummy from Patagonia.

3. Parrish's *Practical Pharmacy: Third Edition, thoroughly revised and improved, with important additions. With* 238 *Illustrations.* Philadelphia: Blanchard & Lea, 1864. pp. 850.—The present edition of this valuable work contains many improvements, adapting it to the wants of apothecaries, physicians and students, and, in general, brings up the topics of which it treats to the present standard of the science and art of pharmacy.

In successive editions a work of this character naturally grows upon the author's hands. In the effort to insert all that is valuable to the different classes of readers for whom it is designed, it is more difficult to

tell what to omit than to find new matter of interest. So far as we can determine, the author has preserved a happy medium, and has furnished a new edition of an already popular work, which admirably maintains the high character universally accorded to previous editions. Many new and valuable illustrations have been introduced in this edition, and the publishers' part has been well executed.

4. *Verhandelingen der Koninklijke Akademie van Wetenschappen.* Amsterdam. *Vierde deel*, 4to, pp. xxxiii, and 572, *Tables d'Intégrales Définies*, par D. Bierens de Haan: and *Achtste deel*, pp. xii, and 702, *Exposé de la Théorie, des Propriétés, des Formules de Transformation, et des Méthodes d'Evaluation des Intégrales Définies*, by the same.—These two volumes are here placed together, although the first has been issued several years, because the second is its natural supplement. In the *Tables* are collected and arranged, in a form convenient for use, six or eight thousand definite integrals. One who has ever had occasion to use a definite integral not familiar to him, one the indefinite form of which does not admit of being expressed in finite terms, can appreciate the value of this collection, merely as a dictionary. In no part of the Mathematics are errors so easily made, as in obtaining the values of definite integrals, and nowhere are errors more difficult of detection. Results obtained by one analyst are often pronounced false by another. For this reason, it is of very great value that with each definite integral is given a reference to the memoir, or volume, where the process of obtaining it is explained. The bibliography thus furnished is of great importance.

It was most natural that this second volume should follow the first. After collecting and arranging the forms of the various known integrals, it was to be expected that a collation of theorems and methods, and an extension of many of them should follow. The evaluation of over two thousand new integrals is but one of the results in this second volume.

Report, Historical and Statistical, on the collection in Geology, Zoology and Botany, in the Museum of the University of Michigan, made to the Board of Regents, Oct. 2, 1863, by A. Winchell, A.M., Prof. Geol. and Botany. 26 pp. 8vo. Ann Arbor, Michigan, 1864. The collections in Zoology and Geology at the Michigan University are among the best in the country.

A list of Animals dredged near Caribou Island, Southern Labrador, in July and August, 1860; by A. S. Packard, Jr. 30 pp. 8vo, with 2 plates.—From the Canadian Naturalist and Geologist, Dec. 1863.

Report of the Astronomer in charge of the Dudley Observatory, for the year 1863, 44 pp., 8vo. Albany, 1864.—This report by G. W. Hough, contains an account of the condition of the principal instruments of the Dudley Observatory, with discussions of methods of adjustment, etc.

On the Nomenclature of the Foraminifera; by W. K. Parker, Esq., and Prof. T. R. Jones, F.G.S. Part X. 13 pp. 8vo.—From the Ann. and Mag. Nat. Hist., for Dec. 1863.

Lectures on the Elements of Comparative Anatomy; by Thomas Henry Huxley, F.R.S., Prof. Nat. Hist. in the Roy. School of Mines, and of Comp. Anat. and Phys. to the Roy. College of Surgeons. London, 1864.—The inaugural volume of a series; it consists of some 300 pages, 112 of which are devoted to a sketch of the classification of animals, and 190 to the structure and theory of the vertebrate skull.—*Reader, May* 21.

Matter and Force (Kraft und Stoff); by Dr. Louis Büchner. Translated by J. F. Collingwood. Stated to expound and carry out the evolution theory of nature to its extreme logical result of no God, no spirit, no immortality.

Blackwall's Spiders of Great Britain and Ireland. Part II. Roy. Society. London, 1864.—Treats of the *Theridiidæ*, *Linyphiidæ*, *Epeiridæ* and *Scytodidæ*.

Histoire Naturelle des Araignées; by M. Eugène Simon. 450 pp. 8vo. Paris, 1864.

Dictionnaire Général des Sciences, edited by MM. Privot-Deschanel and Ad. Focillon, with the collaboration of such men as Barral, Foucault, and Marié Davy 1st part, 650 pages, A to C. Paris, 1864.

La Kabylie et les Kabyles, Esquisse géologique et geographiques; and Le Sahara, ses differents types de Deserts et d'Oasis; two pamphlets by E. Desor. From the Bulletin of the Soc. des Sci. Nat. de Neuchâtel, 1864. 1864.

L'Année Scientifique et Industrielle, ou exposé annuel des travaux scientifiques, des Inventions et des principales applications de la science à l'Industrie et aux arts qui ont attiré l'attention publique en France et à l'étranger; par Louis Figuier. Huitième année. 558 pp. 12mo. Paris, 1863. L. Hachette et Cie.—The subjects are introduced under the heads of Astronomy, Physics and Mechanics, Meteorology, Chemistry, Hydrography (in the course of which there is much in condemnation of Maury's notions), Natural History, Travels, Public Hygiene, Medicine, Agriculture, Industrial arts, Academies and Learned Societies, Scientific Necrology.

Annals of the Lyceum of Nat. Hist., of New York, Vol. VII, Nos. 13–16, Dec. 1861—Feb. 1862.—p. 367, Analytical Synopsis of the Order of Squali, and revision of the nomenclature of the genera; *T. Gill.*—p. 414, On the extension of the Carboniferous system of the U. States so as to include all true coals; *R. P. Stevens.*—p. 420, On certain species of N. American Helicidæ; *T. Bland.*—p. 449, On the occurrence, within the limits of the U. S., of Bucephala Islandica; *D. G. Elliot.*—p. 455, Descriptions of six new species of Birds of the families Charadridæ, Trochilidæ and Caprimulgidæ; *G. N. Lawrence.*—p. 461, Catalogue of a collection of Birds made in New Grenada by J. McLeannan, with notes and descriptions of species; *G. N. Lawrence.*—p. 480, Descriptions of two new species of Mollusca of the genus Corbicula; *T. Prime.*—p. 482, Description of new species of Venus; *T. Prime.*

Vol. VIII, No. 1. May—October, 1863.—p. 1, Catalogue of a collection of Birds made in New Grenada by J. McLeannan, with notes and descriptions; *G. N. Lawrence.*—p. 14, On the family Proserpinacea, with a description of a new species of Proserpina; *T. Bland.*—p. 17, Remarks on Classifications of N. American Helices by European authors, and especially by H. and A. Adams and Albers; *T. Bland.*

Proceedings of the American Phil. Soc., Philadelphia, Vol. IX, No. 70.—p. 234, On Solar Spots; *O. Reichenbach.*—p. 271, On the number of vocal sounds foreign to the English language; *P. E. Chase.*—p. 283, On the diurnal variations of the barometer; *P. E. Chase.*

Proceedings of the Acad. Nat. Sci. of Philadelphia, No. 2, March—April, 1864.—p. 51, Additions to the catalogue of Stars which have changed their colors, or which have appeared with different colors at different times; *J. Ennis.*—p. 57, A new Labroid genus allied to *Trochocopus* Gthr.; *T. Gill.*—p. 59, Note on the nomenclature of genera and species of the family Echeneidoidæ; *T. Gill.*—p. 62, Notes on the Birds of Jamaica; *W. T. March* and *S. F. Baird.*—p. 72, Critical review of the family Procellaridæ: Part I, embracing the Procellarieæ, or Stormy Petrels; *E. Coues.*—p. 92, Synonymy of the species of Strepomatidæ, a family of fluviatile Mollusca inhabiting N. America, Part 3d; *G. W. Tryon, Jr.*—p. 105, New species of Mordellistena collected in Illinois; *C. A. Helmuth.*—p. 106, New species of Birds of the families Cærebidæ, Tanagridæ, Icteridæ and Scolopacidæ; *G. N. Lawrence.*—p. 108, Six new species of Unionidæ from Lake Nyasea, Central Africa, &c.; *I. Lea.*—p. 109, Six new species of Succinea of the U. States; *I. Lea.*—p. 111, New species of Planorbis; *I. Lea.*—Thirteen new species of Melanidæ of the U. S.; *I. Lea.*—p. 113, Five new species of Lymnæa of N. America; *I. Lea.*—Two new species of Unionidæ from South Africa; *I. Lea.*—p. 114, Twenty-four new species of Physa of the U. States and Canada; *I. Lea.*—p. 116, Critical review of the family Procellaridæ, Part II, embracing the Puffineæ; *E. Coues.*

Proceedings of the Essex Institute, Vol. IV, Jan., Feb., March, 1864, No. 1.—p. 3, On the sodalite at Salem, Mass.; *D. M. Balch.*—p. 6, On magnetite and an unknown mineral at Nahant; *G. H. Emerson.*—p. 7, Notes on the family Zygænidæ; *A. S. Packard.*

This Society proposes to publish a Naturalists' Directory, to be issued in connection with the quarterly numbers of its Proceedings, "to contain the name, address and special department of study of every naturalist in the world, whose address can be obtained, under such a classification as will be most convenient for reference." Naturalists are requested to send their address and those of others with whom they may be in correspondence, to F. W. Putnam, Essex Institute, Salem, Mass.